Elliott, Lingley, Kilroy & Sheehan
Worcester, Mass

A System of Instruction in X-Ray Methods and Medical Uses of Light, Hot-Air, Vibration and High-Frequency Currents

THE author is one of the most illustrious teachers of electro-therapeutics in America.

—Medical Sentinel.

FROM such a practical observer and teacher as Dr. Monell one must accept his results as from one qualified to dictate.

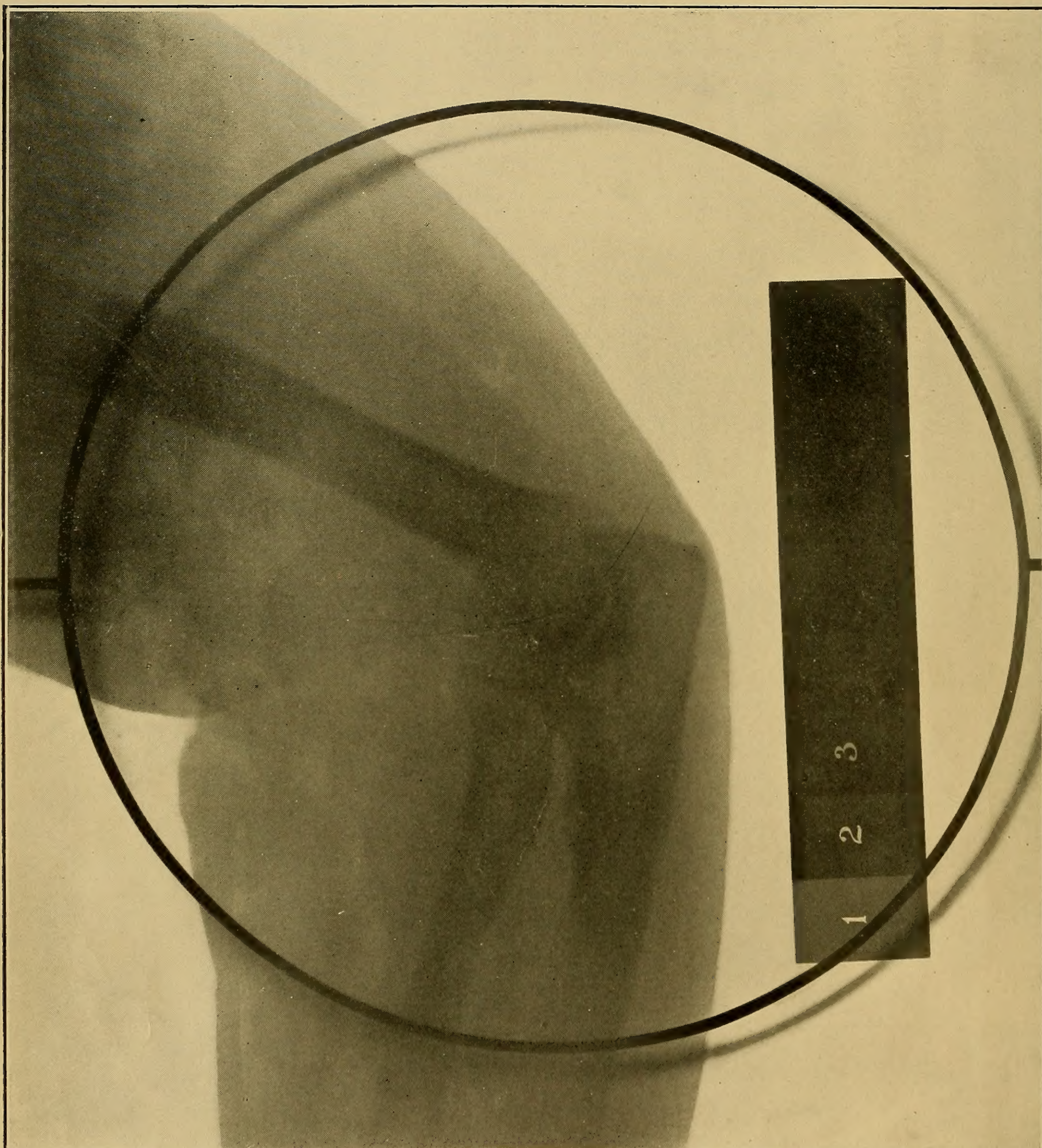
—Canada Medical Record.

DR. MONELL is regarded as one of the foremost thinkers of the medical world, and in electro-therapeutics has done more for Static electricity than any other living man. His voluminous writings have made for him a living history. His books on the uses of electric currents in X-ray work and in electro-therapeutics have had an enormous sale. As author, teacher, scholar, he is at the top.

—The American X-Ray Journal.

WITHIN the past few years there has been a remarkable increase in the use of the Static machine, and one of the foremost in advocating and popularizing its use in the profession has been Dr. S. H. Monell. He has also forced the recognition of the Static machine as a means for producing the X-ray, and that against determined opposition. A visit to his office gives no indication of ostentation or exaggeration, but convinces one that he is moderate in his claims, and has accomplished what he has by hard work and unremitting attention.

—Cleveland Medical Gazette.



The first "Medico-Legal" Radiograph ever published, Proving Technic of Exposure by Evidence Imprinted in the Negative when it was made.

DESCRIPTION OF INSTRUCTION PLATE PROVING TECHNIC OF EXPOSURE

By Evidence Imprinted in the Negative when it was made.

The 8 x 10 plate was centred by the Author's Position-Finder by the first method, using the eye only, as shown in Instruction Plate No. 53.

By means of the Author's Penetration Gauge a tube was regulated to produce a radiance of X_3 for the purpose of the exposure. The X_3 represents the power of radiance at the distance at which the exposure was made. (20 inches in this case.)

In the negative three laps of the Standard Register show and prove that three layers of the metal were penetrated. (See description of this device.) It is shown to be a very low power of radiance.

The sharply defined circle is the lower circle of the Author's Distortion Landmark, proved by the clearness of its shadow to have been close to the film. The blurred circle proves the position of the upper ring of the landmark. That the two shadows of the circles are nearly but not exactly the same size proves that the tube was nearly but not quite exactly 20 inches from the film. The variation is slight. That the two rings are not in exact register proves the direction and extent that the focus was out of centre. The slant of the blurred circle proves that the focus was a trifle too far in the diagonal direction shown by shadows. (Nearly up the line of the humerus.) In the negative the greatest space between the two ring-shadows is ¼ inch, and the Divergence Chart shows that to slant the shadow this much the focus was just 6-16 of an inch out of a plumb-line dropped through the axis of the circles of the distortion landmark which define the X-Ray field in this exposure. Considering that the sighting was done off-hand, using only the eye without any measuring instrument to centre the plate, the result is accurate enough for absolute legal evidence and *the proof of the accuracy is in the negative itself*. A part two inches thick would have no distortion.

The clear circle proves the boundary of the diagnostic field. The nearness of the elbow-joint to the centre of the axis of the rays is self-evident. The final fact that a total penetration of X_3 is not active enough to make the exposure at 20 inches sufficient for the bones also appears proved by the negative. It suffices for the soft parts.

In writing the above the author states the facts from the original print. So much is lost by a reduced half-tone that the student will fail to fully profit by the lesson unless he makes a similar exposure and studies the result at first hand. This plate illustrates the value of four of the author's aids to medico-legal accuracy in X-ray work, and affords self-evident proof, not only of the result, but of the technic of the exposure. It is the first radiograph of the kind ever published, and should be studied with care.

When held up to light the original negative of this picture shows three laps of the Register. The exposure was three minutes. A second picture made had five minutes' exposure, and the negative shows five laps of the register. This indicates that when a radiance of X_3 (as measured at 20 inches by a gauge of sheet brass No. 28) acts on a sensitive film at the same distance each layer of penetration takes one minute of time. Thus, to secure in one minute the effect of five minutes with X_3, we should use a radiance of X_{15}, which can easily be regulated by the current dosage and the spark-gap.

A SYSTEM OF INSTRUCTION

IN

X-RAY METHODS AND MEDICAL USES OF LIGHT, HOT-AIR, VIBRATION AND HIGH-FREQUENCY CURRENTS

A PICTORIAL SYSTEM OF TEACHING BY CLINICAL INSTRUCTION PLATES WITH EXPLANATORY TEXT. A SERIES OF PHOTOGRAPHIC CLINICS IN STANDARD USES OF SCIENTIFIC THERAPEUTIC APPARATUS FOR SURGICAL AND MEDICAL PRACTITIONERS

PREPARED ESPECIALLY FOR THE POST-GRADUATE HOME STUDY

OF

SURGEONS, GENERAL PHYSICIANS, DENTISTS, DERMATOLOGISTS AND SPECIALISTS IN THE TREATMENT OF CHRONIC DISEASES, AND SANITARIUM PRACTICE

BY

S. H. MONELL, M.D.

NEW YORK

Professor of Static Electricity in the International Correspondence Schools; Founder and Chief Instructor of the New York School of Special Electro-Therapeutics; Member of the New York County Medical Society; Member of Kings County Medical Society; Charter Member of the Roentgen Society of the United States; Formerly Editor of the Electro-Therapeutic Department of the Medical Times and Register, 1894–8; Author of "The Treatment of Disease by Electric Currents," "Manual of Static Electricity in X-Ray and Therapeutic Uses," "Elements of Correct Technique," "Rudiments of Modern Medical Electricity," etc., etc.

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PREFACE

This work is essentially a new departure in medical literature. Neither the surgeon's library, nor post-graduate schools, nor Correspondence Instruction supplies the special instruction set forth here. The Camera has been called upon to translate the clinic into a Pictorial System of practical information, and it is believed that it has done it successfully.

The great adjuncts to the materia medica and surgery which are considered in this Pictorial System of Instruction include modern scientific X-Ray Diagnosis, X-Ray Therapeutics, the revolutionary development of Electric-Light Therapy in its three forms, the efficient Therapeutics of Superheated dry air with improved Hot-air Apparatus, the important Therapeutics of Vibration-Apparatus for Mechanical Massage, and the practical but yet unfamiliar Therapeutics of High-Frequency currents from attachments to X-Ray Coils.

The author's purpose is to teach methods that the reader can use in his own work. X-rays are worth nothing to the practitioner till he knows how to use them. Then a good apparatus pays for itself several times a year. The natural relationship between chemical rays of light and the radiations from a Crookes tube fit the two subjects for study together, and the author has sought to bring what is now known of Photo-therapy into as plain and practical familiarity for personal use as he has brought X-rays. The study of these twin offspring of electricity has become imperative in importance.

Directions for the employment of hot-air apparatus are here for the first time put into clinical form and pictorial clearness. Every practitioner who prescribes massage or needs it will be greatly indebted to our section on Vibration therapeutics for the personal use of the physician—a great advance on manual massage. An instructive study of "High-Frequency" currents will show every surgeon or physician who has an X-ray coil how to use it for valuable medical effects similar to those of Static electricity. The clear and condensed text, the directions for a vast variety of methods, and the photographic pictures of technics aim at furnishing the reader at home with the advantages of clinical instruction without the cost. The ease with which the instruction plates and text can be followed will be appreciated after a single hour's study.

Credit Mentions.

The author here desires to express his obligations to medical journals, and especially to the *American X-Ray Journal*, the *Archives of the Roentgen Ray* (London), and to the *Journal of Physical Therapeutics* (London), without whose courtesies this work must have lacked much of its completeness. We have made free use of material from their valuable pages. Colleagues who have kindly contributed to this work will find due mention in appropriate places in the text, and in addition the author here makes grateful acknowledgment to all for every assistance he has received.

To Former Students and Readers.

Physicians who have any of my four previous text-books, published during the last five years, are informed that no part of any of them is contained in this work. This volume is wholly new and original and covers other ground.

THE AUTHOR.

New York, 1902.

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Studies in X-Ray Diagnosis

"*The clinic of Trendelenburg in Leipsic in many respects is the peer of any. The ample and superbly appointed department for Roentgen photography must impress every visitor. Hundreds of magnificent skiagraphs illustrative of many and varied pathologic conditions accurately classified are exposed in convenient cabinets.*"—Impressions of German Surgical Clinics. By Dr. Eastman.

CHAPTER I

WHAT ARE THE X-RAYS?

A Short Study—Becquerel Rays and Their Uses.

The announcement of Roentgen's electrical discovery of invisible light rays, which he called "X," first reached America by cable from London on January 7, 1896. Since then the world's resources in science have studied them, and a hundred pages would not hold an abstract by title merely of the investigations and theories of the first year. These theories are of no practical value at the bedside or in the physician's office. It is agreed that X-rays are vibrations of unascertained wave-length, and as heat waves, sound waves, light waves, electric-current waves, etc., have made the student of pure science familiar with vibratory waves of many lengths and velocities, he is satisfied to regard X-rays in the same way. But what we want in practice is a working knowledge of *how to use them* regardless of what they *are.* The simplest truth that can be stated of their nature is that X-rays are a modification of electric-light rays, and the student who consults our section on photo-therapy will be satisfied to classify them in this way.

An electrical discharge suddenly meeting a sufficient resistance produces (as does a flint struck on a resisting surface) a flash of light. In the arc-light the resistance is an air-gap. In the incandescent lamp the resistance is in a filament placed in a partial vacuum. In the Crookes tube the resistance is a break in the electrical circuit placed in a sufficiently high vacuum. The operating principle of transforming electrical waves into light waves is similar in all and differs mainly in degree. The spectrum shows that composite light is made up of many rays, among which are heat rays, chemical rays, and actinic rays of active properties but without luminous effects on the eye. Some of the most useful radiations of whole light are therefore invisible, and in this respect X-rays resemble them.

The striking difference between X-rays and other invisible light rays, and which makes them the diagnostic agent they have become in the surgeon's hands, is their greater power to excite fluorescence in certain chemicals. Many rays have a little power of this kind, but X-rays of light have so much more power that they have been deemed unique and mysterious beyond well-known light-rays which really have similar properties on a small scale. We accordingly regard rays of X-light from electricity as a modified form of the invisible chemical rays of whole electric arc-light (the modification being due to the conditions of generation), and no other view of the nature of X-rays is demonstrably any truer or more useful to the practitioner than this.

Now let us consider certain facts on which the majority of investigators are agreed. The X-ray is the product of an intense electrical bombardment upon a dense metallic surface situated in vacuo beyond a gap in circuit; the bombarding stream across the vacuum gap is a cone-shaped discharge from the negative electrode in the exhausted tube; it is called the cathode stream; cathode rays are the first step-up transformation of the current beyond the point of direct conduction; they have none of the higher qualities of X-rays; when they focus to a point and strike the polished platinum wall of the positive electrode (anode) the collision under high strain and pressure transforms the lower cathode-ray into the higher X-ray.

X-rays radiate from the front of the positive electrode in straight lines as do rays of ordinary light. They diverge as do rays of ordinary light radiating from a spot or point. In the field of their discharge they *ionize* the air and make it a conductor of electricity. Many of the phenomena associated with X-rays are proved to be *electrical* phenomena. X-rays cannot be reflected, refracted, or concentrated by lenses, but they diffuse themselves by colliding with particles in their paths and producing minor secondary X-rays. They can only be employed as transmitted light, hence camera effects are impossible. But they act on photographic films like rays of ordinary light, though with activity varying according to quantity of rays, intensity of discharge, and distance from the anode source of energy. The fluorescing power of X-rays diminishes rapidly as the distance from the tube increases, a loss of luminosity familiar to all who read at greater or less distances from any other source of light. Their power of stimulating and over-stimulating the nutrition of the skin and its appendages diminishes still more rapidly than does the fluorescing property, and has a much shorter field. Bodies of even small thickness and density in the path of the rays rapidly diminish their power of causing fluorescence, and still more rapidly reduce the power of altering nutrition. After passing through tinfoil or thin aluminum the X-ray goes on with its active dosage diminished, and if a thick sheet of lead is interposed its dosage is rendered *nil*. This reduction of active dosage accounts for the "protecting" effects of screens in radiography.

Every physician and surgeon should have a general reading knowledge of the history, physics, experimental data, and development of the X-ray before using it in practice, and a number of ordinary text-books now cover this ground. The original paper of Roentgen's should be read by all. The scientific side of the study should not be wholly neglected, though little of it is practical. But this course of instruction in technics does not contemplate pages of well-worn matter obtainable in other ways or already familiar; our purpose is to teach the *uses* of X-rays so that practitioners can make them profitable, and at the start we assume that some idea of the subject has been gained before, and we leave further details to develop as we proceed. One thing may be said here ere we pass to another sort of ray.

Thus far there is no known action of the X-rays which is not also a known action of already known forms of electricity. X-rays are invisible: so is an electric current. X-rays radiate from a source in diverging rectilinear lines: so do the rays of an electric light. X-rays affect the photographic plate: so does electricity and the electric light. X-rays will pass through the body and make a picture: so will rays of electric light. X-rays fluoresce certain chemicals: electric discharges do the same. X-rays affect the tissues in peculiar ways: electric currents can (and have) set up similar actions in every way. The main difference is not one of kind, but of *degree.* If X-rays penetrate the tissues, so do electric currents; but *the power of producing fluorescence* after passing through tissues and thus giving visibility to parts within parts is possessed by X-rays in so much greater degree than by electricity in other forms of discharge that it has made them seem *unique.* They are unique only in the higher degree of an action which other electrical discharges parallel in feebler degrees. They will not appear quite so mysterious hereafter if we consider them in the light of electrical discharges.

Becquerel Rays.—At various times during the past few years physicians have read accounts of "X-rays," not from a Crookes tube requiring costly apparatus for its operation, but spontaneous rays given off by certain substances, among which the most active is uranium. The daily press has almost led us to suppose that in due time we could discharge the vacuum tube, and with a lump of metal in our pocket have a portable source of X-rays, minus all operating expenses and lasting forever. But these much-talked-of Becquerel rays get no farther than the first stage. They feebly act on a sensitive film, they faintly fluoresce a barium screen, and they slightly penetrate solids, but as, even with the most powerful preparations thus far obtainable, it is not possible to see the bones of the fingers, the surgical value of this ray is *nil.* Exposures of the hand lasting more than an hour gave no trace of the bones. The rays diffuse so rapidly in passing through substances that they lose their utility. Even were this not the case, another difficulty exists in the fact that various substances that can be very readily examined with X-rays are about twenty times more opaque to Becquerel rays. No one can now foresee any prospect that these rays will attain direct usefulness for medical and surgical purposes, but it is possible that they may be indirectly useful. Recently there comes a report that Grummach has applied Becquerel rays to enhance the effect of X-rays in the following manner: "A screen of fine linen was impregnated with a solution of uranium—the source of Becquerel rays—and suspended between the vacuum tube and the subject so that the X-rays passed through it. The shadows cast on the fluoroscope were much clearer and more distinct, and the contrasts were sharper than by any other technique. The finished radiographs were likewise exceptionally distinct, even with obese subjects." Similar reinforcement has been accomplished with other ray-producing substances, and in this direction of research great results may lie. Uranium is now scarce and more costly than diamonds, however.

The physiological effects of radium rays may possibly develop something of more practical use than their feeble fluorescing properties. We may yet have in this substance a therapeutic agent of practical value. The first report of early experiments was made in June, 1901. In a note in a French journal, MM. Becquerel and Curie give an account of various painful experiments which have been made in connection with the study of radium rays. The first martyr to science in this connection was Giesel, who placed a radium preparation in a celluloid case strapped to his arm for two hours. At first the skin showed only a slight reddening. About two or three weeks afterward inflammation set in. M. Curie was the next victim. He exposed his arm for ten hours and on the twentieth day following had a very sore arm requiring a bandage. On the forty-second day the arm began to get well, but even on the fifty-second day a discoloration showed where the surface had been affected. M. H. Becquerel placed a very active radium preparation in his waistcoat pocket for six hours. The resulting sore took ten days to develop and forty days to heal. Several others had similar experiences, and all who have worked with very active preparations experience pains and sores in their fingers which take two months to recover.

Pergram's instructive paper on radio-active substances and their radiations gives the most concise account of this subject that we have seen. Medical readers would be astonished at the amount of investigation these many rays have received, but space limits us to practical work. It is also without value to cite tables and tests of relative "absorptive" powers of the different tissues of the body and solid substances. A little work with a tube will teach more of these matters than the most tedious text, the plain facts appearing to the eye more clearly than in description. An opaque metal or thick solid that cannot be seen through by the rays is said to have "absorbed" them, which only means that the dense barrier has stopped rays which are unable to pass through it.

CHAPTER II

THE X-RAY EXPERT

Lines of Self-Education.

The extent to which X-ray work had developed in this country was revealed with pleasing emphasis on December 13 and 14, 1900, in the city of New York, when for the first time an organized gathering of results was made and individual accomplishment and separate research met together. But at once it was seen that uniform methods of high-class X-ray technics must be placed before all operators in this field to give results a uniformity of value. Subjected to the test of comparison many of the written descriptions of methods in the books of the Nineteenth Century became ancient in a single day and the need of Twentieth Century Instruction was imperative.

When grouped together the strides that four years had taken in expert knowledge and X-ray workmanship were seen to surpass the early expectations of conservative practitioners and to require rather a standardization of what was best in the achievements of the present than waiting aloof till " advances " of an imagined character should yet come.

Another year has passed, and the X-ray is ready to serve both surgeon and physician with proved efficiency when accepted with rational pre-requisites to results. Its aid to the surgeon depends on the use he makes of it, but modern surgery without the X-ray is an unthinkable proposition at this date. It also knocks with more confident claim at the door of the therapeutist and now seems to be an unmistakable factor in the treatment of certain diseases. Its part in dental diagnosis is almost a story of romance, so far-reaching beyond the eye and all other probings does its key unlock. Its record on the sensitive film or visible image on the screen reveals the seat and nature of many hidden lesions, and it will do much in great variety for him who learns to make it the servant of his wishes. It is an instrument for the progressive practitioner.

Tentative experiment has settled many things. Improved appliances have greatly outgrown their transition stage and are now constructed on better lines. Revolutionary changes have taken place in assisting factors as well as in the electrical mechanism of equipment. The chief gap in the needs of the student is instruction in how to get the best work out of the best apparatus he can now buy so that he can equal in his own office or hospital the reported work of others. The author has undertaken this Pictorial System of Instruction with a view to fill this gap and to supply the correct information in plain language. It is a difficult task not previously performed by anyone, and till better done by some more competent hand this treatise may help the novice along the path of experience and over tribulations.

We are inclined to regard the X-ray section of this work as the author's most valuable bequest to the profession, for it seems inevitable that, once their utility is known, the triple-armed value of the X-ray coil and the X-ray static machine must carry one or the other into every surgical and medical office, sanitarium, and hospital, wherever diagnosis is a science and therapy is progressive. For this reason, and to broaden the student's mind in a rational and comprehensive grasp of the important subject, a great many small but *significant* details have been grouped together in these chapters. Tests and time will disclose their worth, and nothing less than conviction of the necessity of these teachings would have induced the author to present them. Much of the writing so far published has been history, narrative, theory, argument, and report; actual working-directions have been few and far between.

The X-ray has been "epoch-making" in more senses than one, and while an "enthusiast" can in some ways over-state its diagnostic indispensability to a particular surgeon or physician no one can yet measure the total ultimate debt of twentieth-century therapeutics and practice to the professional awakening which is resulting from it. He who investigates X-ray apparatus will learn of other meritorious things related to it that need only to be known to find scores of uses in the hands of 50,000 colleagues. It is, in fact, impossible to now practise medicine without needing the aid of selected and strikingly efficient apparatus, which is revolutionizing rational treatment of disease in the wake of the X-ray. Therefore, to the practical technics of the X-ray we shall here give the close attention they deserve, believing that the instruction thus set forth will exert a greater influence for good than any other task to which we can direct our pen.

How to educate himself along lines that will most speedily enable him to do competent work with this important adjunct to both surgical and medical diagnosis is the first concern of the beginner. When he has been instructed by experience and become expert his knowledge will possess the following scope:

1. He will know how to operate the exciting electrical apparatus with skilled control of the current.

2. How to manipulate tubes with skilled dosage and regulation of radiance.

3. How to place the patient, or part to be examined, with proper fixation.

4. How to place the tube in correct relation to the part.

5. How to make an accurate Fluoroscopic examination and interpret it.

6. How to make an accurate picture with clear definition in the negative.

7. How to read its shadows for correct diagnosis.

8. How to make and manage therapeutic exposures.

These are the *essentials* of X-ray utility. There are *three* main subdivisions in the uses of the X-ray. The difference in the objects sought in each use varies the technique accordingly. These subdivisions are:

1. Fluoroscopic illumination of general shadow-pictures on a screen before the eye.

2. The creation of shadow-pictures on photographic plates.

3. The use of the X-ray as a medical remedy.

All the manifold uses of X-rays resolve themselves into this brief list, as all the words of our language need but twenty-six letters. Learn the X-ray rudiments which spell the variations of X-ray work, and all practical combinations become possible when you understand the *units*.

As medical study is divided into the two branches of Theory and Practice we will first consider the necessary X-ray *theory* as a basis for practical work. The first theoretical question that arises is the nature of X-rays. The vague answer of the scientist is that they are "vibrations of the ether." The same thing is said of electricity, sunlight, electric-light, and Crookes "radiant matter." As this answer yields very little information to the physician treating a lupus with X-rays or a surgeon locating a bullet or diagnosing an obscure condition of a joint, we will pass at once in the next chapter to a study of the place of Roentgen's discovery in scientific diagnosis.

CHAPTER III

MODERN AIDS TO ACCURATE DIAGNOSIS

A Comparison of the Diagnostic Values of X-rays with the Microscope, Stethoscope, Ophthalmoscope, Cystoscope, Endoscope, Specula, Sounds, and other Instrumental Procedures. A Striking Study of the Supremacy of the Eye in Diagnosis.

Diagnosis requires many helps—and needs *more.* As the eye is the chief factor in examinations directed to diagnosis, so we see that the greatest of the great instrumental aids to clinical examinations are directed to aid the eye of the examiner. When ultra-conservative medical men begin to ponder on the possibility of X-rays being yet sufficiently developed to be worth *looking into,* we need only remind them that they bring new and rich tribute of information to the eye, and whatever reinforces sight is worth " looking into."

Leaders in radiography may deem it superfluous to cite evidence of the value of Roentgen's gift to the profession, and so it is to them; but as a practical teacher of physicians during the entire X-ray era the author is well aware that many a practitioner has not yet seen a Crookes tube glow at all, while thousands of others cannot yet set a tube in action or interpret a negative. All such will desire and welcome an adequate presentment of the just claims of X-rays to confidence as demonstrated by reliable workers, and the sacrifice of space will be of little moment compared with saving hesitating and still uninformed colleagues from wasting years in perplexity and doubt before taking to themselves this important adjunct to medical and surgical practice. For the benefit of the beginner and to afford comparison with other diagnostic instruments, we herewith present two masterly reviews. The first is from the President's address for 1899 before the London Roentgen Society,* and illustrates what was accomplished long ere this date.

" There is no branch of medicine or surgery which does not afford abundant evidence of the improvements which have taken place in the production and utilization of X-rays. The fluoroscope has now

* Archives of the Roentgen Ray.

reached such a degree of perfection that with suitable apparatus the minutest movement of the heart and lung, and the least change in the action of the diaphragm can be watched and studied at leisure in the living subject. Photographs of the most deeply buried bone can now be obtained without difficulty. Measurements of such structures as the pelvis can be taken directly by a simple process without subjecting the patient to the least inconvenience. And the clinical records are full of instances showing what has been done and what can be done in medical and surgical practice.

"An account of these which would be in any way adequate would fill a volume, but there are some of so striking and definite a character, that a brief summary may be attempted. Many disorders which even after the discovery and the first application of X-rays were regarded as almost impossible of certain demonstration, such as aneurisms of the thoracic aorta, interlobular empyemata, mediastinal abscesses, and patches of central pneumonia, can now be shown upon the screen with the greatest distinctness, and localized with absolute accuracy. Photographs can be taken of enlarged mediastinal glands and of other intra-thoracic growths. The illumination of the fluoroscope now is so steady and uniform that the earliest stages of tuberculous lesions in the lungs can be seen and recognized, partly by the curiously stippled shadows which they cast, partly by the visibly impaired movement which accompanies them—a fact which has not escaped the notice of some of those who are connected with life insurance. Cavities in the lungs, whether containing air or pus, can now be detected at once, and the position and depth from the surface accurately mapped out, so that a question of the advisability of drainage and operation is once more coming to the front. The presence of adhesions; the alteration in the level of pleural effusions in different positions of the body; the distinction between sub- and supra-diaphragmatic collections; and the existence of cysts or tumors projecting from the upper surface of the liver and raising the diaphragm can now be shown with the greatest clearness. And the same may be said of changes in the position of the heart, and in the size and shape of its chambers, whether brought about by disease or by strain thrown upon their walls by difficulties in connection with distant vessels. They can be distinctly seen with the screen and can be watched from day to day, especially in those cases in which, owing to the presence of emphysema and the absence of cardiac dulness, the ordinary tests fail to give any information. There is, in short, scarcely a thing in connection with the lungs and the heart and great vessels which cannot now be seen and photographed; scarcely a disease of the chest or the organs which it contains concerning which the most valuable information cannot be obtained.

"To such an extent has the fluorescent screen been improved, and so easy has investigation with it been made, that I am convinced that some day (and probably at no very distant date) the examination of a patient's chest with it will be considered as much a matter of routine and as little to be neglected in all doubtful cases as an examination with the stethoscope at the present time. Valuable as are the indications given by the ophthalmoscope in obscure diseases of the brain, they are not to be compared with those that can be obtained by systematic and skilled use of the fluorescent screen in diseases of the heart and lungs.

"The benefit which surgery has derived from improvements which have been effected in the use of X-rays is no less striking. Military surgery has been rewritten. Thanks to the ease with which apparatus can be employed in *base* hospitals, all the wearisome and intensely painful probing after bullets and foreign bodies to which the wounded looked forward with such dread have been swept away. The actual position is defined at once, and the track that it has made is left to heal up of itself. Shot and portions of percussion caps and even the minutest fragments of metal have not only been localized in the eye, but their exact shape and size have been ascertained with so high a degree of accuracy that they could be removed by the most direct route through the smallest possible incision. Bullets, the position of which inside of the skull could not even be conjectured, have been successfully localized and extracted from the brain.

"Foreign bodies, such as plates of false teeth, which have been swallowed accidentally or have dropped into the air-passages; others introduced in the course of operation; splinters of bone, pins, and needles of various kinds, wire sutures, fragments of glass which have been buried perhaps for years, and numberless other substances have not only been made visible, but have been marked out as accurately as if they had been lying in some perfectly transparent medium, so that they could be excised or not according to the degree of inconvenience which they caused and the relative danger of the operation.

"The largest proportion and the most striking cases of advantage have been furnished by injuries and diseases of bones and joints. Those only who have experienced the difficulty of determining whether a fracture or a dislocation or both may not be present in the neighborhood of such a joint as the elbow, when the soft tissues around are so swollen that no bony prominences of any kind can be felt, can realize the immense help given by a well-lit fluorescent screen. It is no question now of long exposure or of keeping the patient, perhaps a child, frightened and suffering pain, quiet for a considerable part of an hour, or even under an anæsthetic. A minute is enough. The nature of the injury is apparent at once, and, what is even more valuable, it is no less easy afterward to ascertain whether the fracture is properly set or the dislocation completely reduced. If the screen is of service to physicians in the diagnosis of intra-thoracic disease, the records of the past year have shown by numberless instances that it is no less valuable to surgery by enabling them to make sure at a glance that the bones are in their proper relation without touching the splints or giving the patient a moment's pain.

"*Diseases* of bones and joints are benefited by the X-rays no less than injuries. Thanks to improved methods the hip-joint can now be radiographed with certainty. All the strange appearances which were so misleading, and which were due in large measure to the distortion produced upon the photographic plates *by faulty position* can be eliminated. The various forms of congenital dislocation can be differentiated from each other, and from such complaints as coxa vara, which are attended by deformity of a somewhat similar character. The fate which overtakes bony grafts implanted into defects have been watched as plainly as if the grafts were on the surface of a limb instead of deeply buried in its substance.

"Diseases such as sarcomata, tuberculous deposits, central abscesses, necrosis, and the like, which, when they occur in deeply seated bones are often exceedingly difficult to recognize and distinguish from each other, have been made perfectly plain. Cavities hitherto almost inaccessible without operation, such as the frontal and sphenoidal sinuses, have been brought within reach of the probe. Valuable help has been given in the diagnosis of antral and other maxillary tumors, and a serious blow has been inflicted upon the reputation of the "bone-setter" who, now that the position of even the smallest bone can be shown to the patient in a photograph, has been compelled to alter his phraseology if not his questionable practice.

"Nothing more illustrates the immense improvement which has been made in radiography than the detection of renal calculi. Until 1899 the instances in which they had been photographed and verified by operations were few and far between. Success had been attained only in the case of very thin and anæmic patients. Now the detection of renal calculi can be looked forward to with a fair degree of certainty, and which is even more valuable, as saving patients from unnecessary operation, the evidence can be trusted equally well when it is in the negative. In all ordinary cases it may now be said that if no calculus is seen there is no calculus to see.

"There may have been no startling new discovery—such do not occur every year—but *there is no single method or part of the technique in which the advance has not been immense. Important as radiography has already become, I believe the position to which it has attained is as nothing as compared with that which awaits it. There can be no doubt that the results will continue to improve and very likely at a more rapid rate than they have done already, and that in a little while, not only will every institution connected with medicine, but every practitioner will be equipped with suitable apparatus.*"

Obtaining his experience independently in another land Kümmell thus reviews the value of X-rays in practical medicine and surgery:

"In addition to their value in the detection of foreign bodies they have become of special value in military surgery. Pathological dilatation of the œsophagus may be shown by them. Both dilatation and stenosis may be made apparent by inserting into the organ either in bulk or in gelatine capsules some metal salt like bismuth which is sufficiently opaque to the rays to define the existing condition. Sounds may be also employed in connection with the X-rays in dilatation of the œsophagus, as well as in gastric dilatation if the sound lies against the wall of the œsophagus or the greater curvature. Foreign bodies in the intestinal tract may also be located by means of the X-rays as well as Murphy buttons and foreign bodies introduced for therapeutic purposes. The X-rays are of value when there are suspected pathological concretions, although up to the present time gall-stones have been detected rarely by this means. Vesical calculi can generally be easily detected by the X-rays. The facility with which these foreign bodies can be detected varies according to the chemical constituency of the concretion. Concretions composed of urates and oxalates are less translucent than phosphatic calculi. Both incrustated as well as non-incrustated bodies, hair-pins, etc., are easily demonstrable by means of the Roentgen rays. Considerable progress in the detection of renal calculi has also been made, and here also the thickness of the soft parts as well as the translucency of the concretion renders its detection more or less difficult.

"The triumphant success of the X-rays in medicine is well known to have been due to the detection of fractures, luxations, and diseases of bone. Roentgen rays have been of great value in diagnosing and treating congenital luxations of the hip. The differential diagnosis between congenital luxation and coxa vara is presented in an interesting manner by the X-rays. Syphilitic, tuberculous, and osteomyelitic thickening and deposits in the large and small long bones are not difficult to recognize by means of the X-rays, and it is interesting to observe how under treatment a tibia that before medication appeared as a narrow shadow upon the radiograph, gradually increases in volume. Similarly, small pathological changes, such as tuberculous deposits, may also be diagnosed.

"Among the tumor-formations large, broad osteo-sarcomata are characteristically portrayed by the X-rays. Nothing of account has yet been attained in detecting other tumors of the body by this means, as the contrast of individual tissues is not sufficient to be of diagnostic value externally. The shadows of the liver and kidney as well as the convolutions of the fetal gut may be plainly seen, but less so in the adult. Fecal masses are easily recognized.

"Chemical substances introduced from without for therapeutic or diagnostic purposes, especially the iodine compounds, can also be plainly seen. Iodoform-glycerin injected into tuberculous joints remains there for a long time and is absorbed slowly. Here the Roentgen picture teaches us that it is not necessary to leave a great amount of this mixture in a joint, as small quantities being also slowly absorbed, fully meet the therapeutic requirements. Iodoform-glycerin injected into fistulous tracts is of diagnostic value in that it penetrates to the bone and permeates extensive sinuses. Characteristic results have been obtained in the recognition of myositis ossificans. Arteriosclerotic changes in the blood-vessels yield very plain X-ray pictures. Considerable progress has been made in observing the intrathoracic changes. The dilated lungs of emphysema, and the lungs in pleurisy and empyema are plainly seen by the X-rays and a pneumothorax which clinically could not be established with certainty was diagnosed without a doubt by means of the Roentgen picture. Lung cavities are easily detected. Peri-bronchial changes appear as sharply defined nodules of variable size. The shadows of the heart, aorta, and aneurisms as well as mediastinal tumors have repeatedly been employed for diagnostic purposes.

"The employment of the X-rays for therapeutic purposes has yielded excellent results in the treatment of lupus. It is to the treatment of skin diseases that the therapeutic efficiency of the X-rays has been principally confined. Other skin diseases that have been successfully treated by this means are chronic eczema, vascular nævus, hypertrichosis, favus, and sycosis. Considerable has been attained since five years by this epoch-making discovery of Roentgen, but much more will be attained during the present century."

From the perusal of these authoritative yet merely skeletal etchings of a great subject let us now turn to other diagnostic instruments which are so familiar that they need no index to their services. Without reminders in this text the reader can weigh the diagnostic services of the microscope and the training it takes to use it well; he can imagine himself without the stethoscope and estimate how much he would miss it; if in general practice, he can recall how often he uses his ophthalmoscope, and cystoscopes, endoscopes, specula, sounds, etc., and their value can be speedily passed in review. Then may come exploratory incisions for diagnosis, examinations of the blood, urinalysis, germ cultures, and all other adjuncts and aids to modern means of finding out what ails the patient. Add to them the X-ray. Then compare its relative possibilities. Learn also to appreciate and use them.

The Twentieth-Century surgeon is armed with tremendous possibilities, and when we have had the X-ray as long as we have had the microscope, stethoscope, and other instruments, the full measure of its resources may present a more striking comparison than to-day.

One thing more remains to be said: A poor microscope can be purchased; a poor stethoscope is not hard to find; cheap instruments of all varieties abound; but in estimating the value of the work each type of instrument will do no author makes a poor and cheap specimen the basis of his teachings. Apply the same rule to the X-ray. Much of the past X-ray literature has been necessarily based on apparatus very greatly inferior to the best now made, and allowance must also be made for the fact that early technics were hardly a fair basis for final scientific conclusions regarding the capabilities of X-rays. With these thoughts to modify our judgment let us seize the lamp of experience as we now find it lighted, and with its yet too-feeble rays to guide our study, press forward to higher developments with practice.

CHAPTER IV

X-RAYS IN THE AVERAGE OFFICE

A Story of Practical Utility and Profitable Results.

While *instruction in technics* is the first aim of the author in the preparation of this work, yet to many medical men in what may be called country towns the question of whether they need X-rays at all requires an answer before technical methods enter into the subject.

Does the practitioner doing general medical and surgical work in communities of from 2,000 to 20,000 population need an X-ray apparatus, and what will he do with it? How will he make it pay?

To answer these important questions the general literature of the subject ought to be sufficient, but much of its force escapes the reader *till he sees the actual work done, or does it himself.* A personal narrative, giving the experience of a colleague similarly situated, will be more helpful in settling the problem than many reports from laboratories of specialists which seem too far out of reach or too wonderful to be true. To bring the facts down to a practical basis for the average reader's own office and his own use, we present part of a typical report by just such a practitioner as 50,000 others in this country. What one has done others can do. The writer's description of his equipment is omitted, and we take up his story in the middle:

"Thus, beginning with the appliances described above, the best obtainable at first, and adding to them from time to time as improvements appeared, the work has become gradually more engrossing and effective. The first fluoroscope and tube purchased showed the thinner parts of the body, but would allow no examination of the trunk. Most of the bones could be distinguished, although at the time it required patience and perseverance.

"One of the earlier experiences was in locating a thirty-two calibre bullet in the upper fourth of the thigh. The limb was very thick and the rays poor. After an hour and a half of patient search (with the fluoroscope), despite the fact that the whole length of the shaft of the femur could be made out, it seemed that we must give up, when a slight elevation on the surface of the bone became visible. The spot was marked, and a subsequent successful operation explained the difficulty. The bullet had been mashed flat against the surface of the bone and was so thin that it caused little more shadow than the bone. (A radiograph would have shown it better.)

"In April, 1896, the liver appeared, though somewhat imperfectly, in a photograph. In August a new fluoroscope arrived, and on searching for a bullet in the chest, one day, there suddenly appeared to the delighted vision the shadow of something expanding and contracting at regular intervals, and this proved to be the heart. The liver appeared at the same time, and with it a vivid realization of what an extensive excursion this organ makes with each respiration. The kidneys were discovered later.

"We have examined in all about 400 cases; many with negative results. These examinations include every part of the body, from a thumb in which a needle was lost, to the spinal column, for diagnosis of a curvature. Lack of time prevented our work from being as systematic as the subject deserved, and some of the more interesting cases were not photographed.

"There have been applications for examination by the X-ray from various sections of the country, from people with all manner of diseases; many, of course, absolutely unsuitable for its use. The general public is impressed with the idea that the ray is capable of showing the condition of every organ of the body, and also of demonstrating the mysteries of numerous functional diseases. We have had to examine several patients for imaginary tumors, who would not be satisfied with the ordinary methods of physical exploration. One gentleman assured us that he had been suffering with his abdomen for years, and felt certain that 'something was broke loose inside of him.'

"So far our best results have been in connection with *bone surgery*, the ray being of invaluable assistance both in the diagnosing and also in aiding the treatment of fractures, dislocations, and sprains, as well as deformities and diseases of the bones.

"Our *fracture cases* have included most of the bones of the human anatomy. Only after using the X-ray can one adequately realize what a tremendous aid it can be in showing the exact condition and position of the break, especially when swelling interferes with proper palpation of the part.

"Our method of procedure has been to examine the break with the ray first, then set it, and examine again in order to see if the bones are held well together. Ordinary bandages, starch bandages, and wooden or pasteboard splints offer but little obstruction to the light. I have watched my cases from time to time, not only to be sure of no bad results, but also to note the formation of the callus. It is sometimes two weeks before this new tissue gets dense enough to obstruct the ray sufficiently to be visible, and it takes two or more months for it to appear the same as the rest of the bone tissue.

"Examination of a number of cases of old fracture shows up many defects in the setting of bones which otherwise would not be apparent. One case, in particular, illustrates this point. Before I had my machine I attended a case of fracture of the tibia, caused by a log rolling over the leg. I treated the case in the ordinary way and the man recovered, but for two months afterward he complained of unusual pain and soreness in the leg on walking. Digital examination revealed nothing. About this time I purchased an X-ray outfit, and on examining the leg found a long, sharp splinter of bone which lacerated the muscles when the man walked.

"Among the simple fractures examined I may mention several cases of Colles's fracture, fracture of hand, foot, leg, thigh, and ribs.

"A recent interesting case was a fracture of the elbow, in which the tip of the olecranon and a small piece of the external condyle were chipped off. The ray was, in this case, invaluable, enabling one to get a perfect view and to restore the joint to its original usefulness. Compound fractures have been especially interesting in showing the healing of the bones. In a number of these cases I have brought the bones together with silver wire, which shows up clearly with the fluoroscope as well as in the photographs.

"One case of excision of the elbow is interesting as showing the healing of the bones after the formation of an artificial joint. In one case of this sort the joint was so useful that the patient's friends, many of them, believed him to have had inserted a joint of gold!

"Various kinds of *new growths* are among the most interesting cases; one was an osteo-sarcoma of the fibula.

"An interesting photograph in my collection is one of the hand and forearm of a veteran of the late war, who had a considerable portion of the bone torn away by a shell. His hand was saved only after the most persistent and long-continued treatment, and the X-ray showed the peculiar way in which the bones united.

"Our cases of *dislocation* have not been so numerous as the fractures, but quite as satisfactory. They include nearly all the usual joints, wrist, elbow, shoulder, clavicle, hip, knee, etc.

"One case was sent me by a colleague who, upon first seeing it, was unable to make a diagnosis on account of the extreme swelling. The ray cleared up the matter in a few minutes. It was a case of backward dislocation of the elbow-joint. Another one of my photographs shows a backward dislocation of the knee, produced by contraction of tendons following tubercular abscess of the joint some years before. The bones had become so roughened at their ends, and so fixed in their bad position, that it was necessary to do an excision of the joint. The patient has recovered, and now has a useful limb.

"The ray has helped us with *sprains*, in showing the amount of abnormal mobility permitted by the injured ligaments. Especially in traumatic flat-foot has it given aid both in diagnosis and treatment.

"We have had so many cases of *supposed sprains* which turned out to be fractures, that I am convinced these small breaks have been very generally overlooked. The practical advantage of demonstrating the existence of such a fracture is to prevent too early use of the injured part, which might result in permanent harm. A good illustration of this point is furnished by a patient who came to me recently with a history of an injury to the ankle seven months before, and her physician wrote that he first saw her twenty-four hours after the accident, at which time the parts were greatly swollen. He could make out no fracture, and treated her for a sprain. During the next seven months she made constant but unsuccessful efforts to walk. The X-ray disclosed the fact of an old fracture of the tibia which had united but had probably taken a long time to heal, on account of the parts not being immobilized. During that time the foot became fixed in a bad position and rendered all efforts at walking very painful. Vigorous treatment by massage, electricity, etc., has completely cured her in a comparatively short time. I have had several other similar cases.

" Recently I was called to a young man suffering pain in his ankle, which he had twisted the night before while romping. I examined him carefully and felt sure there was only a sprain, but subsequent exposure to the ray proved, to my surprise, that there was a crack of the fibula near the lower end, which was not deep enough to cause the slightest sign of a deformity. The patient was a heavy man, and, but for the X-ray examination and the consequent immobilization of the joint, I feel sure that he would have had serious trouble.

" The locating of *foreign bodies* in the tissues is also one of the more interesting functions of the X-ray work. Our cases in this line include the finding of pieces of glass, wood, metal, needles, etc. I have a photograph showing a pin in the thumb which is of interest because the pin was so completely lost that an operative search was abandoned. After locating it with the ray, I found it to have pierced the bone and broken off in its substance.

" *Bullet cases* have been particularly numerous. The missile can usually be seen at a glance, and we have adopted a simple method of marking its location.

" Probing for a bullet is both dangerous and unsatisfactory, as, on the one hand, infection may be carried, and, on the other, there is a possibility of diverting the instrument in the wrong direction, on account of the deep layers of connective tissue. I should like to see the old method abandoned altogether, as a relic of barbarism, the examination by the X-ray completely supplanting its use.

" In my first bullet case, the ball had entered the thigh near the hip-joint, and had remained lost nine months, causing irritation most of the time, though not enough to enable me to find it. It was located by the ray just above the knee-joint. My last case, now in the hospital, was one of a man shot with a Flobert bullet, the missile passing between the floor of the popliteal space and the blood-vessels, and being found on the other side of the joint. Two cases of bullet in the leg were most interesting on account of the upward course pursued by the bullet. One man was walking, the other was running, when shot from behind and, curiously enough, the bullet evidently struck the skin when the foot was elevated.

"A little boy with a bullet in the lower end of the tibia informed us that while playing with a supposed unloaded pistol, a fly lit on his knee. He took aim at it, fired, missed the fly but sent a bullet down to the cartilage of the joint. I was able to remove it without seriously disturbing the joint. A bullet embedded in the deep muscles of the neck was easily located, and is yet to be removed. A few months since, in making a life-insurance examination, the applicant informed me that he had been shot in the axilla several years before, the bullet penetrating into the chest and being lost. On careful examination with the ray, I located it, close to the sternum, where, in case of any future trouble, it could be readily accessible. He would have been rejected but for this discovery.

"One of our photographs shows plainly a bullet which entered at the heel, and was found in the sole of the foot near the toes. The largest bullet I have extracted was a forty-four, which pierced the middle of the sternum, passed downward and outward through the right lung and embedded itself in the chest-wall, where I located it. The patient was in a most desperate condition for more than a week, but recovered completely.

"A most satisfactory case was that of a heavily built, thickly set man who was shot in the back of the neck. The ball passed forward, grazing the deep blood-vessels of the neck, struck the lower jaw, breaking it badly, and was located in the muscles of the face. The markings were rather difficult to make, but the operation showed the bullet to be exactly indicated. In one direction the ray had to penetrate from the front of the face to the back of the neck, and in the other direction through the face from one side to the other. The bullet could be distinctly seen by aid of the fluoroscope.

"A similar case was that of a little girl whose brother shot her in the face with a buckshot from an air-rifle. The missile went into the face deeply. The ray showed it distinctly, notwithstanding its small size and the obstruction to the light from the surrounding tissues. It was easily removed.

"We have had one case of bullet in the brain, which we found to be just back of the orbit, that we did not think it safe to remove. The X-ray will penetrate any part of the head, but here, as elsewhere, it shows the outlines of those substances only which are denser than their surroundings.

"In examining the *heart* we have been able to discern variations in size, shape, and position. We have also watched its action, and noted regularity or irregularity of contraction and expansion. The sternum and spinal column both interfere to some extent with a complete view of this important organ.

"The *liver* proves the most satisfactory of all the internal organs, to examine. We are able to make out its entire outline, including both of the lobes, and to judge somewhat of differences in density. I have seen the solidified *lung* in tubercular cases, but the healthy organ seems to be too porous to show. Of late we have made out the *kidneys*, but with difficulty, on account of the spine and pelvic bones. The thickened wall of the *stomach* we have seen in two cases only. The other organs have remained invisible, so far.

"In the early part of our work one of the first cases examined was a young man with a bullet in the thigh. At that time his knee was very much swollen, exquisitely tender and painful. He could not bear the slightest touch or motion without crying out in agony. It was with the greatest difficulty that he could be properly nursed. I feared suppurative arthritis. In those days the machine was of much less strength than at present, and in order to get a photograph of the part his knee was exposed to the ray for four hours continuously. The next day I was surprised to see the patient moving about the bed without pain; the second day he was up in a chair, and the third day he was walking around on crutches!

"A month or two later I was consulted by a naval officer about his son's elbow, which was affected with tuberculosis, and was so much inflamed that no less an authority than Professor Wyeth had advised excision. The father consulted the great electrician, Nicola Tesla, who advised a trial of the X-ray. Acting upon this advice we exposed the joint to the ray two or three times a week for two hours each time, until the total exposure was about twelve hours. After each exposure I applied a wet dressing. In a short time all signs of inflammation had disappeared, and now nearly eighteen months have passed without any return of the disease.

"About eight months ago a colleague brought me a case to examine for gall-stones. For several months the patient had been suffering frightful attacks of pain at frequent intervals. I made a prolonged examination with the ray, without finding any stones. They may have been present and have escaped detection on account of their small size. Strange to relate, however, the man has never had an attack since the examination, and is entirely restored to good health. Two other cases of a similar nature were apparently relieved by the use of the ray.

"There has been absolutely no irritating effect from the ray in any of my cases with two exceptions. The first was the case of tuberculosis of the elbow referred to above. In this case there was a spot of discoloration of the skin, with no sign of inflammation, which disappeared without treatment, in about a week. The other was a boy who had a badly united fracture of the femur. Some difficulty was experienced in getting a good photograph of the limb. Several exposures were made. Two weeks later a dermatitis developed, confined to the surface of the skin and resembling an eczema. It was rather obstinate in healing, but after a few weeks of simple treatment was cured without any bad results.

"I have used the ray in a large number of cases of all kinds. I have myself been exposed to it for hours at a time. From my intimate experience with it I can state most positively that if properly and rationally employed, *there can be not the slightest bad after-effects.*

"I fully realize that this report is an imperfect and incomplete one, but it has the practical advantage of being drawn entirely from personal observation, and I trust that it may be of some interest and use to the profession. I am convinced that, notwithstanding the great good already obtained from the X-ray, there yet remains a broad field for further development."

CHAPTER V

BEGINNERS AND CURRENT X-RAY LITERATURE

Dogmatism. X-Rays and Popular Impressions. The X-Ray in Quackery. Special X-Ray Journals.

When writers on X-ray matters report cases and state facts of experience, as in our last chapter, they contribute much to the enlightenment of the profession and beginners cannot read too many articles of practical instruction. But when theory takes the place of fact and every separate theorist has a different opinion about almost every detail of X-ray work it perplexes the student to sort out the right conclusion.

The point is so important that it needs considering. Only a trained expert with varied experience can rapidly run through a lengthy article and separate the unreal from the real. Yet a little guidance will help the beginner to hereafter ignore some of the contradictions that fill him with doubt and tend to bar his progress. Almost no statement can now be made respecting any feature of X-ray work without finding opposite opinions held by different operators. As many of these obtain equally good practical results this difference of mere opinion must not be taken too seriously by the beginner, for controversy that ends in the same result may safely be put aside.

The *sum* of the world's knowledge of X-ray actions, technics, and apparatus *is now very great*, and any one writer of narrow reading should be quite cautious before stating that *no one else knows* what he merely does not know *himself*. Almost always an article contains internal evidence of the competency of the writer, provided the reader be a judge of competency. But in the event that he is not, then it is a safe rule to follow the reports of actual work done, and to put to the proof all theories before accepting them. The instruction thus gained will be sound and reliable.

X-rays and Popular Impressions.—On the part of the lay-public there is but little knowledge of the true function of X-rays. The sensational press and their funny paragraphers have laid deep and wide the foundation for a century of erroneous ideas about the capabilities and limitations of this means of diagnosis. Many cases of neuralgia think that the cause of their pain can be seen with the fluoroscope as readily as the bones of the hand. Even cases of nervous dyspepsia have requested the author to make an X-ray examination in the off-hand way in which one would ask a physician to look at some casual mark on the skin.

Needless alarm has also been cultivated by irresponsible newspaper reporters in regard to the terrors of submitting to an exposure. An intelligent young lady, aged fifteen, with a dislocated shoulder, exhibited the greatest terror when asked to stand a moment in front of the tube for a fluoroscopic examination which would have produced no sensation whatever. She declared that she "knew it would burn her up, and would hurt awfully." When à nurse took the position and assured her that she felt nothing, the girl allowed a brief examination, but was so nervous and alarmed that she was almost in hysterics. Those who are responsible for the evil thus done are more contemptible than vulgar criminals and cannot offer the excuse of ignorance. It should be the duty of every physician, whether he uses X-rays himself or not, to instruct his patients for their protection against dread and distrust of them.

The X-ray in Quackery.—*The American X-Ray Journal* for June, 1901, makes these wholesome remarks on this subject:

"*The Journal* of ——— recently contained an editorial upon the above subject. Surprise was expressed that *quacks* had not long since taken up this implement, but the editor submitted an explanation that it was due to the requirement of some knowledge of electricity before the X-rays could be used. The article implies *ignorance of science and letters* on the part of quacks. This idea is an error. Medical laws are now quite severe throughout the States, and yet quackery is, if possible, more aggressive now than formerly. If one acquainted with the correct uses of X-rays will carefully look over the literature of the subject, he will see the inroads made by another kind of quacks in the field of this important branch of our profession. It is not always the one who pictures his alleged skill in the columns of the lay-press who most injures the fair name of medicine. *Ignorance* has prompted more articles on X-rays than quacks. In proof of this, see the articles by learned professional men upon the 'inaccuracies of the X-rays,' for instance. It is absolutely known that there is no such thing as an inaccuracy of an X-ray (which can neither be reflected, deflected, or refracted, but pursues its rectilinear course straight to the end). Inaccuracies are the work of the operator, and become less and less in proportion as skill increases. Do we hear about inaccuracies of the law of gravitation? of magnetism? of electrical conduction? of mathematics? of the conservation of energy? of the diffusion of gases? Yet men may make personal errors in mathematical calculations and in the application of Nature's laws.

"Then, too, see the X-ray pictures so frequently used in medical journals. They tell nothing. Many are perfectly blank, black blotches, without detail, and without evidence of the description. No other kind of picture purporting to show something would be used by an editor. Why then these? They should be as delineative as other illustrations are. This effort to do something or say something upon a subject for the self-exploitation of the writer is quackery. More harm is done by scissors work and second-hand theories of illy-informed reputable medical men than by the preposterous circulars of open quacks. One deserves as little weight as the other.

"It is now the custom for the writer of a new surgical book to want an X-ray section written by some eminent man in the profession. It is an honor to get into an accredited work as an author on this subject. The choice is made without regard to the man's lack of ability in actual X-ray work. The task is undertaken, and how shamefully it is handled! These books are not written for novel reading, but for the instruction of the practitioner. He who assumes the rôle of such a writer should first know the subject whereof he writes. Howsoever wise he may be in all other domains, if ignorant in this and yet writes as a teacher, he is essentially a quack."

It is an interesting fact to note that about two-thirds of the special claims made by the few travelling quacks, who sought to achieve profit out of X-rays during the first two or three years following Roentgen's discovery, are now the accepted clinical demonstrations of a large number of physicians of the best professional standing. No ethical nose could go up high enough to express its contempt for any "quack" who claimed to "cure cancer" with X-rays in 1897. The author well remembers receiving a letter full of condemnation and asking advice as to organizing the local profession and running such a charlatan out of town. In another chapter of this course of instruction the reader will find that the treatment of similar forms of cancer is now one of the orthodox commonplaces of X-ray therapy, and he will be fully taught how to do it himself.

Special X-ray Journals.—As medical journals and surgical journals aim to supply practitioners' needs of current literature in these fields, so it is important that practitioners using X-rays in medicine and surgery should have a means of keeping posted on current developments and progress. How little the regular medical journals fill this want is scarcely realized till a search is made for some special article. For instance, a very enterprising weekly journal published in Philadelphia would be cited by many physicians as likely to contain a fair number of papers on this subject. If we are not mistaken its file shows that during the twelve months of 1901 it did not publish a single exclusive original X-ray article, and its "abstracts" on this subject were disappointingly meagre, often being limited to title.

Therefore all X-ray workers will agree that a special journal should report and illustrate the advances in this line. It is not merely wise to support such a journal, but it is *a profitable investment* which cannot be duplicated in any other way. But unless subscribers follow their subscriptions with valuable reports of their own researches, discoveries, new technics, new and useful devices, etc., the journal will not best fulfil its mission. We all know that much of the most important work done is never written up for the general benefit, and a well-sustained X-ray periodical should be rich in original contributions. There are two of these exclusive X-ray journals in the English language, and we are indebted to both of them. Others in time may appear.

The American X-ray Journal has so far been the only exclusive X-ray publication in this country. It was established in May, 1897, in St. Louis, Mo. It is issued monthly, and was the first regular monthly in the X-ray field. To the editor we extend thanks for permission to cite freely from its pages.

In England the transactions of the Roentgen Society of London are officially reported in the *Archives of the Roentgen Ray*. While the American journal was in fact the first regular monthly X-ray magazine to appear anywhere, yet the first periodical publication in the English language after Roentgen's memorable discovery was the *Archives of Skiagraphy*, under the editorship of Mr. Sidney Rowland, and which was speedily enlarged, and from its second volume developed into the present fine *Archives of the Roentgen Ray*. It is published every two months during the session of the London Roentgen Society by Messrs. Rebman, Limited, 129 Shaftesbury Avenue, London, W. C., and we cite valuable matter from its pages by the courtesy of the publishers.

CHAPTER VI

STUDIES IN X-RAY MECHANICS

Current Generators. Trouble Hunting.

The hospital or individual contemplating the purchase of X-ray apparatus needs general information on the different designs from which a selection may be made. The surgeon who has already selected his apparatus needs special information as to its adjustment, care, and operation.

To acquire the first kind of information send for the latest catalogues and quotations of the leading manufacturers and dealers and compare them, with due allowance for the conflicting opinions of competitors. To best acquire the specific knowledge of apparatus just purchased have the seller show how to set up each part of the mechanism, how to regulate it for satisfactory operation, how to care for the whole apparatus, and how to locate faults and correct them. But before making a selection it is best not to be guided solely by printed praises of any apparatus, but go to see it work. Examine various designs and find out the weak as well as the strong points of each. Then a purchase will not be likely to disappoint; or if it does not at first give full satisfaction it can be soon mastered without doubt.

The regular text-books on electricity and X-rays devote liberal space to descriptions of coils, static machines, and lists of accessories. Reiteration is not required for the practical instruction of the students of this course, and we can make better use of the space in teaching methods and technics. But beginners can quickly read a few words of general guidance.

If you think of buying an X-ray equipment first consider just what range of work you will need to do with it. Then investigate your local resources of electrical supply. Can you get the street current in your office? If so, make a note of its type and voltage. If you have no light-circuit and must use a battery, see what room you can give it, and whether you can get a storage battery conveniently charged. A primary battery is the last resort, but can be used if there is no other way. Then take all this data to the selected maker and discuss the design of coil that will best suit the conditions of your office and work. The construction of the coil, the exciting current, the interrupter, the regulating devices, the vacuum tube, and the tube-holder must *fit* as harmoniously as the parts of a watch fit when it keeps time. The essential factors are a fat current of high E.M.F. and a reliable and effective interrupter. The electrolytic types of interrupters do not use a condenser, but mechanical breaks do. If you need a condenser stipulate that it must have ample capacity. Many commercial condensers have too little. Then a heavy current in some emergency causes damage, and repairs cost money.

Condensers vary in size and price and are rated according to "capacity," and depend for their action on the law of electrical capacity. Every electrical conductor has the capacity to hold a certain magnitude of current as a "charge." In measuring the capacity of a condenser the raising of the electrical pressure one volt by a charge of one coulomb is taken as a capacity of one farad; but for practical purposes this is divided into micro-farads, and one micro-farad is the common unit. The practical effect of the condenser is to maintain in the circuit the amount of electrical action which is equal to the capacity of the condenser. Some have only a fixed rating, while some are made with a variable capacity so as to permit of a range of adjustment.

In insisting that the coil itself shall be wound so as to give a thick spark, do not forget that the character of the interrupter greatly influences this. A long thin spark may be changed to a fine thick discharge simply by regulation or change of the interrupter. Old forms of breaks robbed coils of nearly half their intrinsic value in many cases. In former days the question was simple, but now the selection of an interrupter and the regulation of it is one of the most delicate problems connected with X-ray apparatus.

There are now many improved mechanical interrupters; a dozen or more very excellent ones of the spring vibrator type; a few rotary wheel breaks; at least six fast improving mercury type interrupters; a very fine spark-gap device; and, lastly, electrolytic interrupters with numerous modifications. In each type there are very good and very poor instruments.

A really decisive advance in mechanical interrupters was made in the introduction of the "Mercury" form of interrupters, and still undergoing a gradual improvement this device has taken a firm place at the head of all varieties save the "electrolytic." Mercury interrupters developed along three types—the vibrating, oscillating, and rotary—and in Europe where they were used with minor pressures, gave greater speed, and smoother and more continuous working than any previous break with heavy primary currents; but, wherever the street current was chiefly used, all the interrupters so far mentioned were either radically deficient or had not yet been constructed to suit the higher pressures.

Then, like a revelation, in 1899, came the Wehnelt break from Charlottenburg, showing how immensely the output of a coil might be increased and intensity of bombardment gained with coils no larger and currents no higher than had been used before. The curious simplicity and astonishing method of the electrolytic device of Wehnelt not only led others to modify the type and aim to develop greater endurance and regularity while removing some of the obvious drawbacks of the initial models, but almost at once suggested the adaptation of mercury interrupters to more rapid rates and heavier discharges and pressures. The "jet" principle of action was the result, and has developed a break which can be adjusted to all frequencies from 100 to 50,000 periods per minute, is almost noiseless, compact in design, extremely durable, of flexible regulation, and applicable to any circuit up to 250 volts. It is a break of very high efficiency at the present time, and unless the electrolytic interrupter can be perfected the mercury jet will bid fair to hold first place among these essential arms of the coil. As 1902 opens still newer mercury types give higher efficiency still, and promise to lead the field in practical work.

A third factor which must bear a mutual relation to the current-generator is the tube. Particular statements about coils will not appear to be true *unless tubes are suited to the character of the bombardment from the coil*, but bearing this in mind it may be stated as a good general rule that a very long spark is not alone the measure of efficiency, and ordinary workers do not require apparatus giving maximum sparks of twenty, twenty-four, or more inches. Do not trust to the mere *length* of any discharge. Look at it closely and from quite another stand-point. With the eye study its degree of "fatness," for a lean spark of even two, or three, *feet* is not the ideal for X-ray work. It must be *relatively thick*. What would be "thick" for a six-inch discharge would be thin for an eighteen-inch discharge, but a thick bombardment from a medium coil will work a good tube better than a thin bombardment from a coil of much higher rating in mere length of spark.

With the ear listen to the discharge and note if it be sharp, tense, detonating, with evidence in it of volume, pressure, and disruption, which the ear can detect better than any of the other senses. The driving force and fatness of a high-efficiency bombardment, once heard by a novice ear, can never be mistaken afterward for the light sputtering of a thin volley. Note also if the discharge is *smooth and even* in regularity; or if it is mixed and jerky. The bombardment must not only be intense and full of quantity, but it must be mechanically regular and sustained.

The longer the spark-rating of the coil the higher resistances in tubes it will drive the current through, hence larger coils will excite tubes that have passed beyond four, six, and eight-inch pressures. But the fluorescing efficiency in the X-ray output of a tube increases in proportion to *the quantity of current in the bombardment*, and with high voltages a high amperage becomes rapidly heating at the point of high resistance. Therefore anodes must be made to carry extra heat if they are to be used with what are called "heavy" currents, and, owing to a combination of practical reasons, including the higher cost, we need not seek extremes of voltage and quantity, but rather a satisfactory working *medium* which will serve all ordinary purposes in medical and surgical employment.

It may therefore be held that twelve to fifteen inches is long enough for a spark rating if the volume is thick in proportion and if the interrupter is right and the tube suited. With such an apparatus a fair degree of skill will enable the operator to meet nearly all emergencies. The main aid to fine work will not be a larger coil, but selected and up-to-date accessory devices which do so much to bring out the fullest measure of capacity in the foundation part of the equipment.

Various operators have suggested modifications of the Wehnelt break. Holding forth as it does the most alluring promises of X-radiance beyond any otherwise obtainable, it has been a veritable tantalus in actual work. Men read that it has been robbed of its smell; that it has been made permanent in durability; that it no longer chokes; that it will work with the alternating as well as the direct current; that it has been made readily controllable; that it will suit any tube; and living witnesses find on test that it breaks all these promises and needs yet further improvement before it can take its place among the reliable accessories of the X-ray coil.

Still, it is true that ingenious individual experimenters seem to accomplish what the majority fail of doing. Thus, a writer referring to European progress in radiography recently stated: "Somehow, by using large volumes of electrolyte (fifteen quarts), and by suiting the self-induction of the coil primary to the working pressure, our continental friends appear to obtain more satisfactory conditions with this

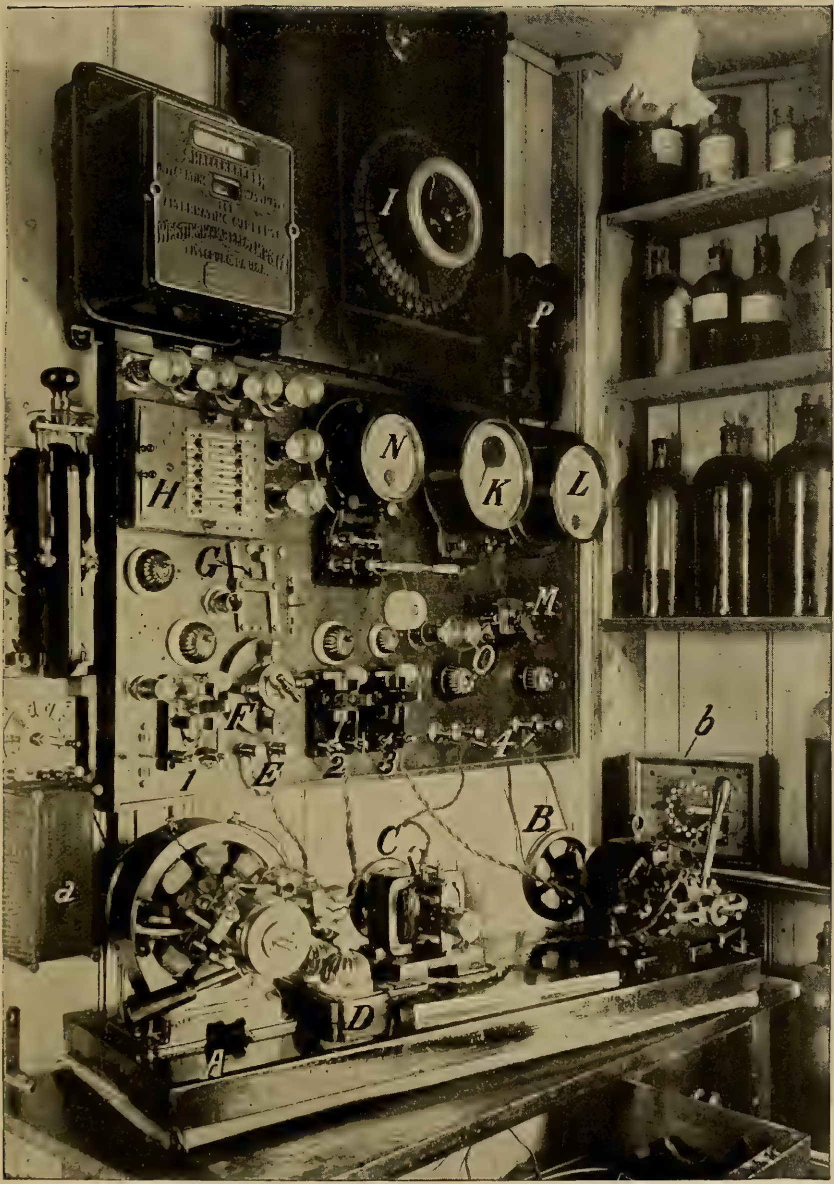
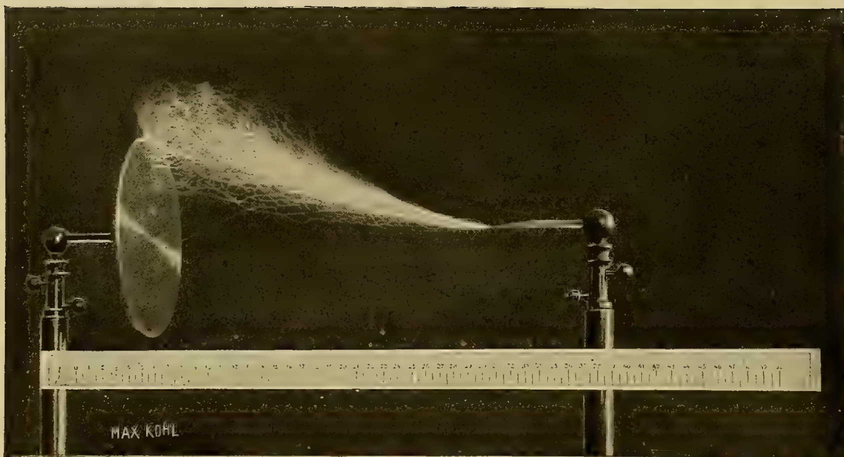


PLATE 1.—Illustrating the switchboard and rectifying device of an English Surgeon who operates a continuous-current coil with an alternating-current supply from the street circuit. (Rebman, Ltd.)

No general illustrations of coils, Static machines and X-ray apparatus will be attempted in this book, as they properly belong in the catalogues of manufacturers.

PLATE 2.—Photograph of Spark Discharge on Film. This plate illustrates the effect of an electric discharge of accidental occurrence just prior to connecting a tube in circuit. The photographic plate was on the base of the tube-holder: the patient's hands were on the plate, and the wires from a ten-inch coil were supported by a high stand with their free ends resting on the table within an inch or two of the plate. The current was accidentally turned on for a few seconds while preparing for the exposure. The negative wire was at the lady's right hand. She felt a shock, but there was neither spark nor disruptive discharge seen. No trace of the current could be detected afterward on the plate-envelope. The print shows that the spark reaching the film was a small discharge. Beautiful studies of these tree-fern-like tracings on sensitive films may be made at will by any operator, and it does not require much of a current to fill the face of an 8 x 10 plate with wonderful markings. Each pole makes its own peculiar tracing, and when both discharges meet the front and back of the plate at the same time a merging of effects results which can easily be identified by one familiar with these pictures. (Rebman, Ltd.)

PLATE 3.—Positive Phase of Electric Energy. Action upon the film of a single positive spray discharge from a high potential coil. This fern-like picture of a power in scientific medicine which the profession is only just awakening to study, but which it has happily become a badge of ignorance to deprecate, is reduced from a magnificent photograph 18 by 22 inches in size. It therefore does faint justice to the beautiful original. It is one of a remarkable series of fifty photographs of different electrical discharges, all 18 by 22 inches, made by Mr. Kinraide, of Boston, in experiments with the Kinraide coil. Having seen them all, the author has the greatest regret that it is impossible to present them here in unreduced impressiveness. Without question they furnish the most striking, unique, and magnificent record of electrical discharges ever made. They would have astonished Faraday beyond words.



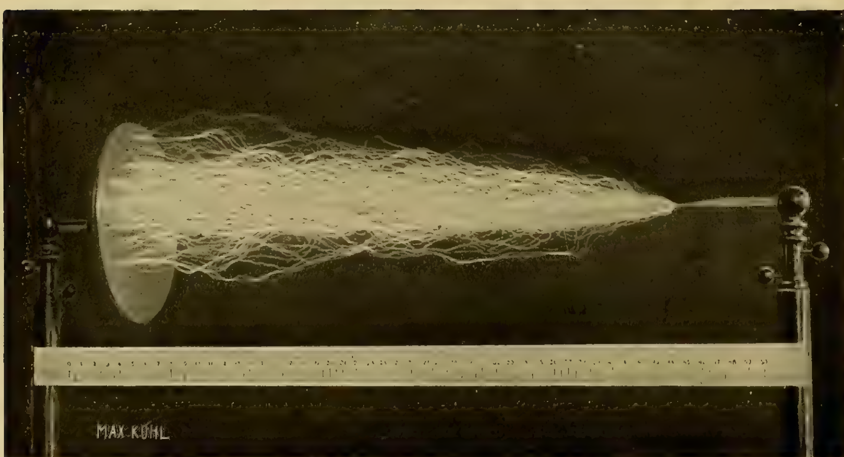


PLATE 4.—These plates illustrate the brush discharge from a sixteen-inch coil with the Wehnelt electrolytic interrupter. Note the difference between the fat stream and the ordinary spark of mechanical breaks. The parallel scale shows the great reduction from the original.

break than has been our experience, for one authority, in strongly recommending the use of the Wehnelt, lays stress upon its quality of *being practically permanent in working, and requiring no attention and no cleaning or repairs for years,* so that it may be placed in a distant room under a flue in order to eliminate its objectionable noise and gases."

In this country it is at present fair to say that for use with the continuous current and with small alternating currents the best types of electrolytic breaks have been improved to a reasonable degree of satisfaction. With large alternating currents most of them break down, but having confidence in human inventiveness we may consider that in due time the worst of the difficulties will be overcome, and that in this form of break will be found the cheapest, simplest, and most direct road to high-efficiency interruption.

Tubes for use with electrolytic breaks must have a rather high vacuum. They also require great heat-resisting qualities in the anode. In early use ordinary anodes were burnt out in a few seconds or minutes. Special and heavy construction now gives durable tubes for these interrupters. As there are many designs in the market, get full operating instructions from the seller for the one purchased. With a perfect electrolytic break a medium coil nearly equals the efficiency of a very large coil. In fact new possibilities are opened up to designers of coils by recent interrupters, which give fresh impulse to the improvement of X-ray apparatus. Changes from old models aim at wire-saving and simplicity with higher efficiency. New accessories can be attached to old coils and thus earlier buyers can keep pace with improvements at moderate cost.

Static Machines for X-ray Work.—If a Static machine is decided on it should be one giving *fatness of current*, and not mere length of spark. This can only be obtained by applying the same principle which gives large amperage to cell-currents, to-wit: the arrangement of many plates (or cells) in "parallel." Diameter of revolving plates gives a great part of the *voltage* of the current. Each added pair of plates in parallel adds to the richness of the current in *quantity*, and this factor, which is so vital to X-ray work, cannot be imparted by speed, size of plates, or any other feature of the Static machine. My own idea of the efficiency of a large current, as compared with a small current, has been obtained from a year and a half of experience with a machine having thirty-two plates (sixteen revolving) thirty inches in diameter. Having begun years ago with a four-plate machine, then a six plate, then an eight plate, then a ten plate, as experience and improved results led to a desire for a richer and thicker current a jump was made to my present apparatus. Nothing that can be put into words can convey a realistic idea of the vastly greater *working-capacity of a large Static current* over the small currents in general use obtained from all machines of all makes and types having only twenty plates (ten revolving) of thirty inches diameter, and sizes less than these.

As we shall at a convenient time re-write and bring up to date our now historic and out-of-print "Manual of Static Electricity in X-Ray and Therapeutic Uses," we deem it needless to repeat here our well-known views regarding the value of this electrical apparatus. When our first volume appeared there were two established manufacturers of Static machines in this country, with a recently added third; that there are now more than twenty in the same field is sufficient evidence that our teachings have been accepted.

Trouble-Hunting.—When an X-ray tube does not light up, what is the matter? Where is the trouble, and how can the novice trace it? When found, how can it be repaired? These are questions of magnified interest to the beginner, and at times even the expert finds in them something to engage his attention.

As there are now in America alone more than thirty different makes of X-ray apparatus, no two of which are alike in all respects, it follows that directions cannot be written *secundum artem* to fit each detail of different construction. But the lamp of experience soon endows the expert with an intuition that emulates clairvoyance, and for the novice certain principles can be laid down that will put trouble-hunting on a practical basis.

In all electrical installations the art of finding and correcting faults in the circuit needs cultivating, for *perfection* and *permanence* are two words not yet incorporated into the lexicon of electrical apparatus. But interruptions of *function* in X-ray apparatus do not always mean accident and injury, nor expensive repairs. On the contrary, with improved modern equipment and reasonable care an injurious accident will very seldom happen, and most of the operators' trouble-hunting will relate to slight faults in the working efficiency of some part that is not properly *adjusted.*

Until skill and acquired perception lead instinctively to the seat of fault make it a rule to trace the current from its origin to the break.

1. Test the source of current supply. Does the generator *generate?* Is there current at the primary poles of the coil or static machine? If not, then the trouble is behind them. But where? Examine the wires and contacts between the terminals and the cells or socket. The basic principle that all wires must be intact and all con-

tacts sound applies equally to a primary or storage battery and to the street current. Inspect them all.

If a fuse has blown out or if cells are run down, a short-circuit test at the primary contacts will show no current present. This soon leads to the exact location of the fault.

2. If current comes up to the coil but fails to develop a full dosage then test the condition of the coil in the following manner: nearly close the spark-rods and switch in the current; draw the rods apart and ascertain the maximum spark-gap; if too short and thin examine all connections and especially the interrupting device. The integrity, clean condition, and adjustment of the interrupter must be one of the first concerns of the operator, and this principle applies to all the types in the market. The coil itself is a passive mass and may be sound, well wound, and perfectly insulated in every part, but the vital centre of activity, which has all the merits of the coil at its mercy, is the interrupter. It must not only be in working order, but it must be regulated for the work in hand. Look at it and test its action before seeking trouble in the coil itself.

So skilled does the operator soon become in locating trifling disarrangements in his apparatus that a rapid glance over contacts, interrupter, and the accessories of rheostat, metres, and such switches as exist in the given outfit will detect and correct the trouble almost in a moment. If there is a real break-down that needs the aid of the repair shop, the beginner will do well not to be too hasty in shipping the apparatus to the maker. First get the invaluable experience of trying to fix it yourself. There is a lot of instruction in such an effort. If it fails and a workman can be called in let him show and explain to you all he does, and next time it may be needed the knowledge gained will be very useful. Trips to the factory are seldom required for high-grade apparatus which embodies modern improvements, and *the best thing to do with poor apparatus is to trade it off and buy better.*

3. If the source of current supply is all right, and the coil and its connections test up without fault, then the trouble may be looked for beyond the terminals, *i.e.*, in the connections of the tube or in the tube itself. If the current is under proper control a contrary action of external wires, contacts, and tube is soon traced.

For the instruction and encouragement of many workers in hospital and private practice, who still employ apparatus purchased in the first or second year of Roentgen's discovery, we think it valuable to cite some remarks made by an expert who himself adheres to such an apparatus.

"If there be any special merit in much of my work, I believe it is due not to new discoveries, but to the consistent adherence to one or two features, especially antiquated. I do not wish to be understood as implying that nothing which is new is good; but rather that much which is old is also excellent. Visitors to my experimenting room, who are at all familiar with modern X-ray apparatus, nearly all exclaim at the very slow speed at which the interrupter is run, and wonder that a form of break so ancient is adhered to. When pictures are shown with exposures varying from three seconds for a hand and wrist to a couple of minutes for a thorax; and when they see a screen brightly illuminated ten feet from the tube, the surprise is none the less marked, but along different lines. There is no doubt that slow interruptions are inconvenient for fluoroscopic work, but they are very efficient when pictures are required.

"Difficulty is often met with in adjusting the interrupter for different rates on account of the sparking which results. In this case the capacity of the condenser is probably not suited to the set of conditions that must be met. In other words, the time of a complete cycle of operations, and *the ratio in which this period is divided between closed and open circuit in the primary*, is of great importance, and is related to the self-induction of the coil and the capacity of the condenser intended to take up this extra current. If the capacity is too small the condenser will be only partially affected, and sparking will result at the break. It is probable that the ordinary commercial coil would be much more efficient if its condenser were several times larger than usually made. I am told by makers that on the commercial X-ray coils, the capacity of the condenser varies from five to fifteen micro-farads. A hasty measurement of my own shows its capacity to be about thirty-five micro-farads.

"Adjustment should be made so that the actual interruption of the primary current shall be as sudden as possible. This results in a rapid variation in the magnetic flux through the iron core, which induces in the secondary a rapidly increasing electromotive force. This act of breaking the primary, however, produces a self-induction in the coil, which in itself tends to retard the suddenness of the break by causing an arc between the points as they recede from each other. If, however, a condenser of large capacity be connected around the break the extra current will flow into that. The condenser evidently must be of capacity sufficient to absorb all the charge that would otherwise tend to jump between the contact points. But a very important part of the phenomenon is yet to follow. The best iron core will not alone lose its magnetism except after a period of time which is considerable when compared with intervals of the minute order which we are contemplating. To effect this necessary result the condenser at once discharges back through the circuit and demagnetizes the core very rapidly, thereby inducing an enormous electromotive force in the secondary coil current.

"If a coil with an insufficient condenser be operated slowly, it sparks badly at the break. If the speed be increased until the sparking is minimum, it is so because the time of 'make.' has been too short to allow the direct current to obtain a maximum. The extra current due to self-induction is therefore less, and the small condenser can take care of it. Obviously, under these conditions, the coil is not operating with maximum output.

"The time of 'make,' when the primary is closed, ought to be just long enough to enable the current to reach its maximum value; the time required depending on the self-induction of the coil as well as on its resistance. The time of break when the circuit is open must be long enough to enable the condenser to be charged and discharged. If the 'make' follows the break too soon the direct current will interfere with the discharge of the condenser.

"Furthermore, it must be remembered that the coil with all its attachments may be in perfect adjustment to be operated as an *inductorium*, pouring streams of full-length sparks between the terminals of its secondary, and yet not be in the best adjustment for *operating an X-ray tube*. The mutual induction between the two coils is obviously not the same in the two cases, and hence the conditions are somewhat modified."

CHAPTER VII

CROOKES TUBES

Present Classes of Tubes. The "Best Tube." Gold Medal Tube. Author's "Static Tube." Hard and Soft Tubes. Punctures. Do X-Ray Tubes Explode? Connecting Wires for Tubes.

More inquiries have reached me during the past five years on the subject of tubes than on any other detail of X-ray work, showing that the average practitioner finds his chief problem the one of obtaining satisfactory Crookes' tubes. In this chapter we shall discuss the more practical side of the subject as it relates to the buyer and user, rather than the maker and experimentalist.

Tubes may be broadly placed in the following classes:

1. Plain two-terminal tubes.
2. Plain three-terminal tubes.
3. Adjustable tubes.
4. Self-regulating tubes.
5. Water-cooled tubes.

As current-generators have delivered heavier and still heavier bombardments upon the anode, and as new types of interrupters have thrown into the focus a greater and greater quantity of heat, it has been a constant struggle for the tube-maker to keep pace with the coil. In the Spring of 1896 the anode was as thin as tissue-paper. Soon tubes were made larger, terminals were farther apart, and the platinum was thickened to a plate. Then a backing to absorb the excess of heat was added by some. Then some of the heat was shunted to a second electrode. In theory a flow of water upon the target would cool it and remove the cause of complaint, and, though expensive, it was tried. Many modifications in the construction of tubes have been made to adapt them to modern heavy discharges, and the best results have been obtained by adapting the tube as a whole to the current used with it, and not by any special single device.

The plain, well-made two-terminal tube renders good average service with a minimum of trouble if it is suited to the apparatus and the operator knows how to manage it. Such a tube often does work of the highest class and lasts indefinitely; but men of less practice may get only ordinary results with similar tubes, or may even complain that they are very poor. The personal equation counts for more than thirty per cent. of the efficiency of any X-ray apparatus. It may at first count for more than half; for when skill is being acquired the process is more rapid with some men than with others and goes farther in some cases than in others. Therefore, the exact efficiency of a tube *per se* is not a fixed quantity but varies according to the man behind the apparatus.

The first "adjustable" tubes had no real advantage over plain tubes, for while resistance could be lowered when it rose to excess it did not stay down. In from one to ten minutes after releasing into the bulb the chemical atoms which increased the conductivity between the electrodes and made the gap less resisting, the atoms took on polarity and ranged themselves in alliance with those already collected at each electrode. By a new discharge of volatilized chemical the resistance could be again reduced, but in practice it was found that a tube which needed this repeated attention was not made satisfactory by it, and that a tube which worked finely seemed to do so quite independent of the "adjustable" feature of its construction.

The next step was the addition of a device to keep the resistance down to a point of definite adjustment without frequent attention from the operator. This made the tube "self-regulating." The first such tubes were very complicated and frail. Very recent improvements have seemed to mark an advance. The potash salt is sealed in a terminal connected with a spark-gap shunt-current from the main circuit. When the resistance varies the current follows the line of least resistance. If this is the line of the shunt-current the reducing salt is acted on till the path through the vacuum is opened, when the shunt automatically closes out. The balance is finely held. The adjustable resistance of the shunt circuit controls the resistance of the main circuit, and the self-regulation of the tube follows the preliminary regulation of the dosage desired by the operator.

Very satisfactory steadiness seems to be maintained in action, and a not unimportant feature is the fact that no outside spark is likely to jump through the glass and puncture such a tube, because the spark finds itself shunted through the regulator where it is harmless. This claim of the makers has been substantiated in such tests as the author has so far made with these new designs.

With means of regulating the dosage of current (and this is especially true with a complete Static machine equipment and training), the plain two-terminal tube of medium vacuum can be varied at will, through all degrees of radiance, from a very small low X-ray output up to a profuse, brilliant, penetrating, and rich light. A single tube may thus serve a variety of purposes and cover all the work for which some claim that half a dozen tubes would be necessary. This flexible adjustability of X-ray dosage with an ordinary tube of suitable initial vacuum must be known to several thousand physicians and surgeons, for the author has been teaching it since 1896. It seems, however, to have escaped the notice of a number of writers. The object of "vacuum regulators" and ingenious accessory devices is nearly the same, but seeks to regulate the vacuum without regulating the current. Both methods are useful in practice.

The Best Tube.—Who makes the best tubes? Which is the best tube? Where can the surgeon get good tubes? During the past four years these questions have been asked by thousands of beginners. The answer cannot be a categorical one. The tube is not an independent device. Its working efficiency depends in part on factors outside itself, and just as a chain can be no stronger than its weakest link, an X-ray tube can be no better than the chain of working conditions. This is not sufficiently understood, even by men of several years' experience, for very few operators make a serious study of skilled *manipulation of tubes.* We may, however, say, first get good apparatus, next get skill in manipulation; then all tubes will fall readily into one of three classes:

Class 1.—Tubes you can make work at once with excellent satisfaction.

Class 2.—Tubes that a brief test will show can be made to work with a little indicated manipulation.

Class 3.—Tubes to reject at once for any of a dozen reasons that tests will demonstrate. Do not buy too "high" tubes.

The adaptation of a tube to a particular apparatus is not quite as narrow as the adaptation of a shoe to a foot or a glove to the hand, but within reasonable limits the tube must suit the electrical discharges, or the electrical discharges must be regulated to suit the tube. If neither of these things can be done by a given operator he had better reject that particular tube and select another which will work with his apparatus.

In order to lessen uncertainty in dealing with the problem of satisfactory tubes the student should first study to acquire the following information:

1. A knowledge of proper electrical dosage for individual tubes.
2. A knowledge of all the varieties of manipulation that tubes require. The technique required for the type of tube in hand.

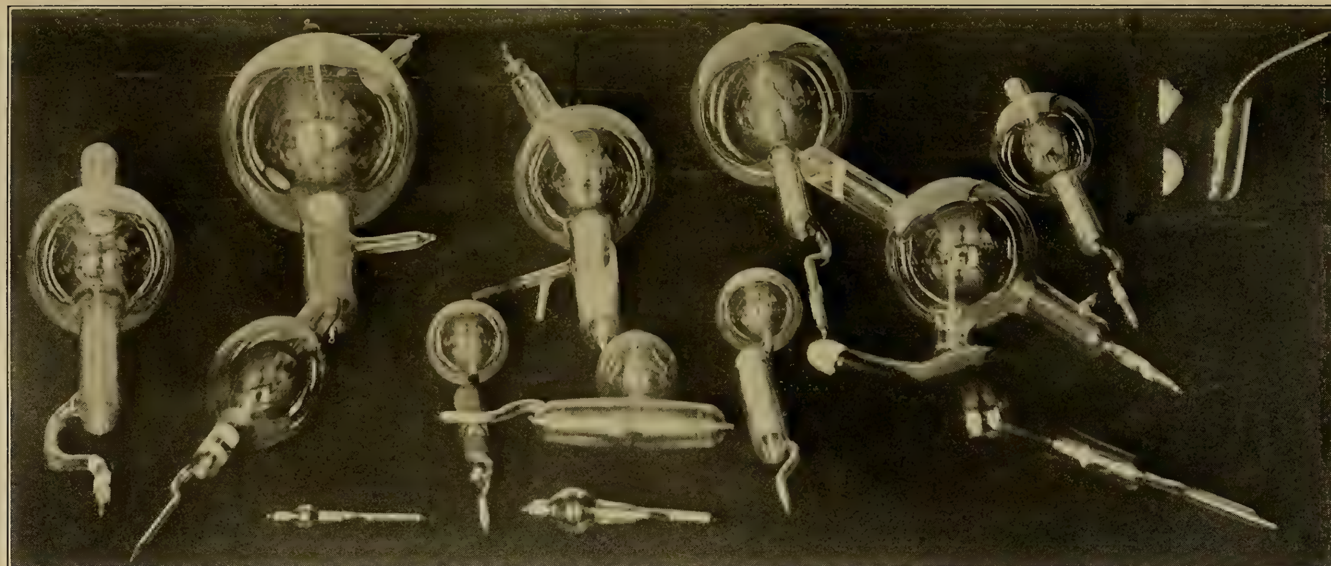


Plate 5.—Showing Various Tubes from the Author's Collection. The large tubes are all modern. One just at left of the centre is a water-cooled tube. At the right-hand corner is an old tube partly coated with black varnish. Near the left corner is the smallest X-ray tube ever made. I have safely excited it with a large 20-plate Static machine. Its bulb is half an inch in diameter. At its right is a fine tube with a bulb one inch in diameter. It has worked well with a large Static machine. The tube second in central line and just above this was the first double-focus tube made in this country. The small tubes were made solely for the author's tests. In the upper right corner are the fragments of the exploded tube mentioned in this chapter. Note the bend in the stiff metal rod and the folding of the electrodes by the force of compression.

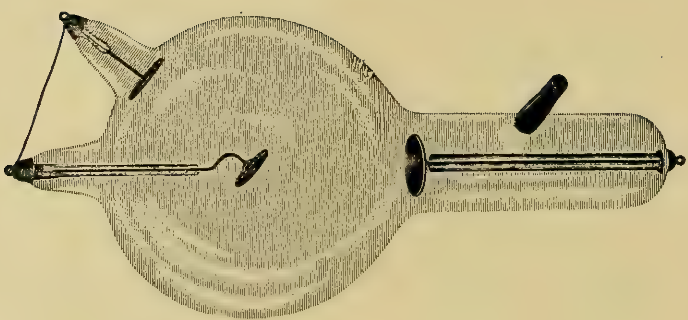


PLATE 6.—The "Gold Medal" Tube. The plain three-electrode tube, winner of the Gold Medal Prize. Of the 28 competitors, 8 were American makers, 5 English, and 15 German. The Gold Medal tube is sold in this country by several importers, and is also made with a self-adjusting auxiliary.

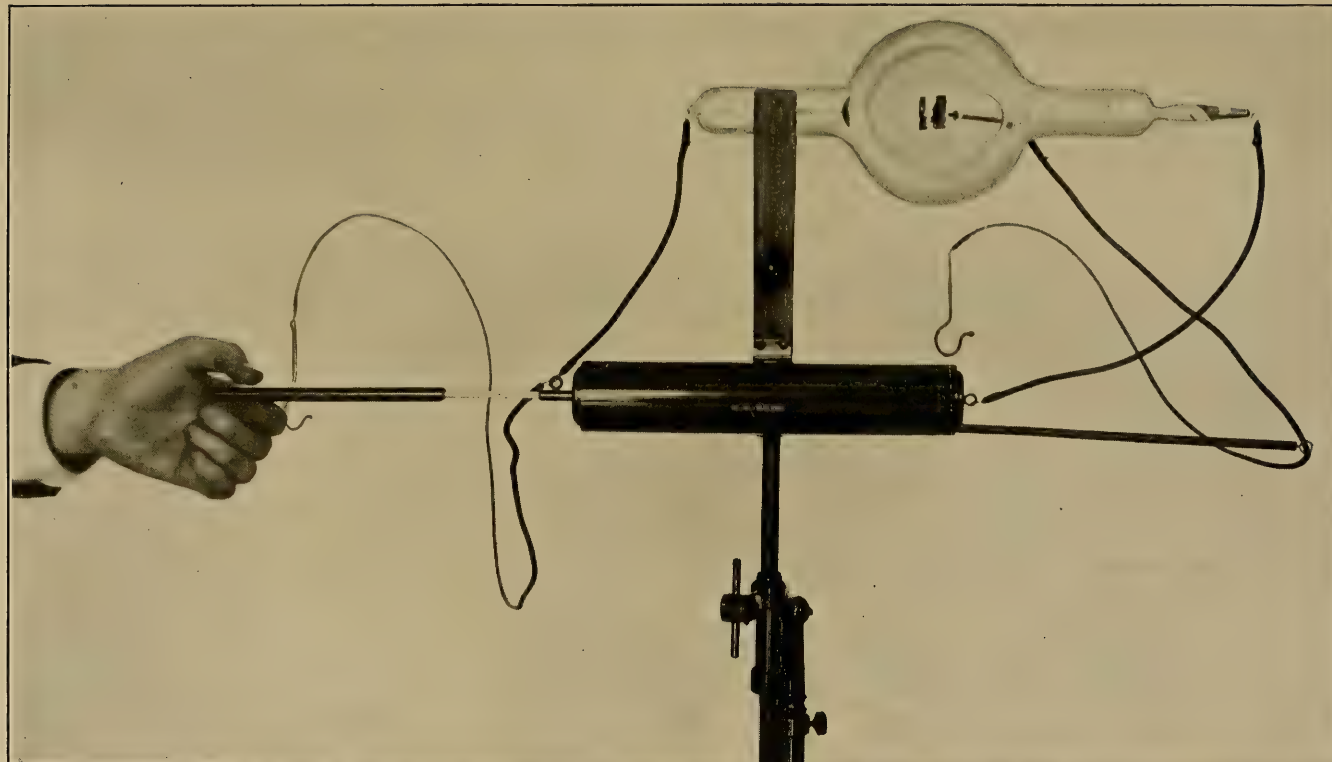


PLATE 7.—The Bario-Vacuum Company Automatic Resistance Regulator. Set up the tube and Regulator as shown in this Instruction Plate. Do not reverse the poles. Attach the left hook to negative and right hook to positive pole of current. With Static machine use interrupter on positive pole. Start current with small spark-gap and rod of regulator pushed in. Develop the desired amount of current and gradually pull out the rod till the radiance is regulated to suit. During continuous use modify the position of rod as needed to keep the action steady.

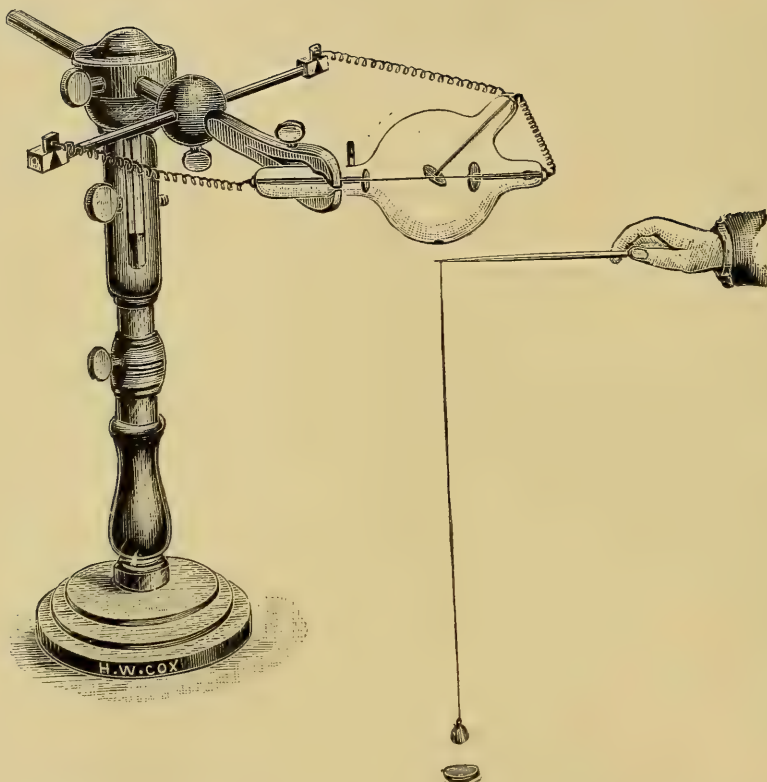


PLATE 8.—This figure illustrates the proper method of dropping a plumb line from the focus of the tube to the centre of the plate or part to be examined in the axis of the rays. Take a thin stick of wood whittled to a point—use no metal—turn around it the silk thread to which the plummet is attached, and employ it as shown in the cut. Care must be used to drop the line from the precise spot of the lower wall of the tube through which the axis of the central ray passes. It will be noted that a line can be dropped only in the perpendicular, while the author's Position Finder is equally accurate and available in all directions and planes. With it a tube and plate can be squared almost instantly in any position required by the case. (Rebman, Ltd.)

3. The ability to detect at a glance during tests all faults of working, and correct them.

4. A knowledge of what actually represents the maximum capacity of a given tube.

5. A knowledge of both the limitations and possibilities of X-ray effects.

6. A knowledge of tests by which to demonstrate the causes of faults anywhere in the circuit with the tube.

It is very easy to know how to tell a poor tube from a good one by a moment's examination and test, but unless the operator has this elementary knowledge no one can answer for him the question as to which is the best tube. First secure the above knowledge by rudimentary study of working principles, and you can answer the question yourself.

Good tubes are becoming much more common now than formerly, and each year will see some improvement. The gold-medal prize offered for a fine tube, in 1901, gave an impetus to manufacture which will be far-reaching.

Gold Medal Tube.—To encourage the production of a satisfactory tube the President of the Roentgen Society, of London, offered a gold medal for the best practical X-ray tube for both photographic and screen work. The conditions were as follows:

1. The tubes are to be exhausted for testing upon a ten-inch spark coil working at eight-inch alternative spark-gap.

2. The tube must be well made and properly capped.

3. The price of the tube will be a factor in the adjudication.

4. The price submitted shall be that at which similar tubes shall be obtainable through usual retail sources.

5. The tube will be tested and marked for—

(*a*) Penetration.

(*b*) Photographic effect.

(*c*) Screen work.

A jury of twelve of the most eminent and scientific men in this field of interest in Europe, including Sir William Crookes and Professor Roentgen, was chosen to test all tubes submitted. They devoted more than a month to the decision, and announced a verdict about July 1, 1901. There can be no doubt of the thoroughness of the tests made nor of the entire ability of the men who made them. No series of tubes was ever before submitted to such an ordeal, and the merit of the selected design must have been unmistakable. The winner of the gold medal was the design of Mr. C. H. F. Müller, of Germany, entered by an English firm. Twenty-eight entries were received for the competition, some of which were excellent as to glass-blowing, but seventy-five per cent. failed to meet the *definition tests* that were the important requirement of the donor. Definition, photographic effect, penetration, and moderation in price were the chief considerations, and the striking lack of the first quality (without which all others are useless) compelled the committee to draw the attention of manufacturers generally to this defect. It is a defect that lessens the value of nine-tenths of the X-ray examinations made in America or Europe, and should be remedied before any other feature of tube construction.

Author's "Static Tube."—Since the wide-spread employment and recognized efficiency of the larger Static machines in X-ray work, the main interest of this particular tube is historical.

Throughout the early half of 1896, Static machines were tried and rejected as unsuited to the best X-ray work. About July, 1896, the author concluded that the dissatisfaction arose mainly from the fact that makers did not adapt the vacuum of tubes then in the market to the peculiar character of the static current, which was then used without interrupters. I do not now speak of small machines which required Leyden jars for operation.

During several months experiments were made with the co-operation of four different makers, and the result was the standardization of the character of tube required for static work, the lifting of the previously condemned Static machine into the first rank of X-ray apparatus, and the publication of the author's epoch-marking article on "Crookes' Tubes and Static Machines," which appeared in *The Medical Record*, February 6, 1897. Makers then began to construct and supply what has been known for the past five years as the "Monell Static Tube." It was always a plain, two-terminal tube, of practical utility, possessing good ordinary every-day qualities of action; extremely reliable, strong, seldom puncturing, and, on the whole, giving very general satisfaction to all purchasers who had skill enough in operative technics.

Several hundred of these tubes passed through my hands, in 1897-98, for personal tests of quality before being sold. The average was excellent. Many were equal to the best tubes of any type. Very few deserved rejection. A single instance, however, may illustrate that satisfaction with tubes depends somewhat on how they are operated. A surgeon came to me for instruction. He was delighted with *my* tubes; said he had two similar ones in his office for a year; could do nothing with one, and could only make the other flicker without lighting up. He was asked to telegraph for them. He opened the box himself, handled the tubes without my touching them in any way, connected up one, and managed it as he had been instructed. It worked beautifully. After ten minutes of fine action he got out the second tube. For about two consecutive hours he rejoicingly operated this tube at very high efficiency without stopping it a moment. He made all sorts of tests with it and was so enraptured at finding that what he had regarded as useless for more than a year were in reality a couple of choice " prizes " that he would not again trust them to the express, but went out and procured a special case in order to carry them home in his own hand. The episode is instructive.

With the introduction of interrupters and general improvements in regulating devices for both currents and tubes, the importance of a great deal of pioneer work has passed. Many varieties of modern tubes will now work well with Static machines, and the adjustment of vacuum is far better understood by makers to-day than it was when the first edition of my now historical " Manual of Static Electricity in X-Ray and Therapeutic Uses " went to press. Many arguments of 1897 are now obsolete. The three-terminal tube and regulating devices have succeeded two-terminal and plain tubes in popular favor.

Hard and Soft Tubes.—During the past year or more it has become common to write of tubes as hard or soft instead of high or low resistance, as formerly. These terms were translated from a paper written by Professor Roentgen himself. I do not know what the originals were, but the translator who turned them into the English *hard* and *soft* did not improve on *high* and *low*, which had become familiar. The words are indefinite, unscientific, and, in reality, are so meaningless that confusion has been added to the subject of tubes by the efforts of different writers to describe exactly what sort of a tube is a hard tube and what sort of a tube is a soft tube. A review of a large number of articles discloses a surprising difference of opinion among writers as to the exact shadings of quality which place a tube under one head or the other, and some seem able to discriminate so finely that we cannot follow them. The common understanding may be that a tube of low resistance is a " soft " tube and a tube with high resistance is a " hard " tube, but the literature of experts show that it is not all so simple as this.

Resistances of tubes are relative to the driving force of the current, and a resistance which would be high for a small current would obviously be insignificantly low for the voltage of a twenty-inch spark. In the interests of practical simplicity, the words hard and soft will not be used by the author. One operator may think he knows what he means when he uses them, but another operator may hold quite a different interpretation of the words, and in the absence of a common agreement they have no value.

Some think hard tubes give off X-rays of great "wave length," while soft tubes give off rays of short "wave length." Some assume that the rays of a soft tube are "absorbed" by the skin, while the rays of a hard tube affect the deeper tissues only. The dogmatic theories met with in current literature will largely fall to the ground in practice, and taking any dozen tubes and running the dosage of exciting current up and down (as can easily be done), it would be impossible to find two men out of ten who would agree in saying how hard or soft they were. Obviously the intent is to indicate an idea of the penetration of the rays, but these vary with any given tube according to the energy of the bombardment which excites it, and *every tube that will do good work at all can be made to do a wide variety of work.* Therefore, the accurate and practical measure of penetration is the author's Gauge described in this book. It will measure the exact penetration employed at any time, with any tube, with any degree of activity, and with any wattage of current. It is commended to the profession as a scientific substitute for guess-work.

In lieu of the gauge measurement, however, it is much better to record and report the resistance of the parallel spark-gap rather than to refer to tubes indefinitely as either hard or soft, or high or low.

A writer in a recent X-ray journal says: "All operators have to admit that no accurate and standard method for determining the quality of the X-ray has yet been devised," but if by "quality" is meant the working factors of the rays in penetration and defining power, then the author's gauge has long afforded an "accurate and standard method." A perusal of Chapter XX. and a personal test of the instrument will demonstrate the facts.

Punctures.—What is a puncture? Why does it occur? How can it be avoided? Can it be repaired? These and other questions occur to beginners. A tube may be *broken* in various ways, but a "puncture" is usually a very small, almost invisible, perforation through some thin part of the wall of the tube, and is caused by the passage of a fine spark between an external terminal wire and an internal electrode or supporting rod. To get from one to the other with the wall of the tube between them, it passes *through* the glass and punctures it.

It may occur upon either the positive or negative side of the tube, and the reason it occurs is a pressure of the electric-current in excess of the normal internal capacity of the tube, or the approach of an attracting conductor from the outside too near the internal discharges. When the current goes easily through the tube punctures do not happen, because sparks do not then jump from either terminals or electrode. Certain methods of technique very rarely cause a puncture. Other methods contain an increased risk of puncture. Methods can be employed which will puncture tubes very rapidly. Experts aim to avoid them.

The glass in certain tubes is more liable to puncture than others. American tubes made of American glass seem less liable to puncture, even with sparking currents. Tubes made here or abroad of German glass, either may or may not puncture easily, but are difficult to repair. Tubes blown very thin in the bulb are not particularly subject to puncture, but extra thickness at the juncture of the bulb with the terminals is important. Bubbles and apparent flaws in the wall of the bulb do not seem to increase punctures. The internal structure may make some tubes more liable to puncture than others. Certain applications of tinfoil to reduce a high resistance increase the risk of puncture in proportion as the foil approaches the cathode or anode and in proportion to the sparking pressure of the bombardment.

Plain tubes made of American glass can usually be repaired, but whether they will be good as new or not will not appear until tested in use. Some repaired tubes never equal their first efficiency, while others are as good as ever. Complicated tubes may be difficult to repair. Certain fine German tubes imported to this country have shattered into a myriad pieces during attempts to repair a small puncture, and it is understood in the trade that repairs are at the risk of the owner.

While in certain cases a puncture will occur despite precautions, yet almost all punctures *are the result of increasing the sparking pressure of the electric-current beyond the internal capacity of the tube.* The higher the resistance of the tube, and the higher the pressure of current, the greater the tendency of the discharge to jump outside the tube rather than pass normally through it. A careful regulation of the dosage of the current to suit the working capacity of the individual tube will reduce the number of punctures to a minimum. A shunt-current regulator is to a great extent a preventive of punctures.

Life of X-ray Tubes.—Barring accidental breakage as distinguished from puncture the life of a tube has but two limitations, viz.: puncture by a spark and burning out by too heavy currents. Practically, however, the life of a tube is considered the period during which it works readily at a satisfactory efficiency.

During excessive use a given tube may temporarily alter its internal resistance and be non-usable for a time, but rest or manipulation will usually bring it back again to a working state.

Heavy electrical discharges generate intense heat at the site of high resistance, and thin anodes may quickly be burnt out by excessive currents. If a number of tubes are carefully used in rotation they recover a normal state during the interval of rest, and will very slowly reach the point of excessive resistance, which soon troubles the beginner who uses a single tube persistently.

Intrinsically, there does not seem to be any natural limit to the life of the tube. If accidents do not destroy it, it will last indefinitely. The author's most fragile tube, with an anode as thin as tissue paper, and an exceedingly thin bulb and handle, purchased in 1896, is still in perfect condition. On numerous occasions it has been kept in action continuously for one and two hours at a time without stopping the current an instant. It always works and gives no trouble. Another tube which had seen four years' service was as good as new when it was broken by being struck with a heavy gold ring on the finger of a student. In a laboratory in Philadelphia were two tubes, which had been on hand for about sixteen years, when Roentgen's discovery was announced. How long they had been in previous existence is not known. I have seen two superb radiographs made with these sixteen-year-old tubes early in 1896.

Physical damage, then, may be considered the only factor in shortening the life of a Crookes' tube. It is claimed that self-regulating tubes do not puncture, for the reason that the shunt-current of the regulating circuit absorbs what might otherwise develop into a spark discharge outside the tube, when the resistance or pressure of the main current becomes abnormal. Shunting off the extra spark protects the tube from puncture. Few of my tubes have punctured, and none in regular use.

Care of Tubes.—It is known that a lamp chimney will tend to crack with the heat if it is wet and cleaned in improper ways. Crude washing of the chimney and drying it with a swab on a metal rod will make the chimney crack when it is suddenly heated.

If a tube becomes finger-marked and dusty, do not wash it in water. Gently blow on it and carefully wipe it with soft tissue-paper. Make it a rule to avoid handling any part of the bulb. Always lift tubes by their *terminals*. Handle them *gently*. Do not screw or clamp them too tightly in a tube-holder. Clamp them with only just enough pressure to retain them in position. Do not allow any *metal* to touch the bulb of the tube. When not in use, keep all tubes wrapped in soft tissue-paper and put away in closed boxes, or in a closed closet to protect them from both accident and dust. When getting out tubes for work, it is best to deposit each one separately on a softly covered table or shelf where they will not roll if disturbed. While tubes may be carefully laid on plates of glass or anything made of wood, yet it is best to avoid anything hard.

In connecting up a tube use care to avoid bending the platinum loops of the terminals. With too frequent bending they will finally break off. When operating with heavy coil currents the care given a tube must extend to watching the anode for signs of excessive heat and also the wall of the tube lest it soften and partly collapse from prolonged heat from an incandescent anode. The indications to reduce the current and cool off the tube must not be neglected. This care relates more to small tubes than to the larger ones now in general use, which do not yield easily to heat.

Do X-ray Tubes Explode?—Is there danger to either operator or patient if an explosion takes place? Readers have perhaps met an occasional alarming reference to these points. It is considered that a tube is subject to more violence *during its manufacture* than during actual use, and if it survive the processes of the maker it will endure use, barring accident. Minute punctures caused by stray sparks simply let down the vacuum and do not break the tube beyond the small perforation. An operator in Boston mentions that one of his tubes exploded while making an examination, and he "narrowly escaped injury to his eyes." On the other hand, an expert with exceptional opportunity stated in a discussion that he had handled over 5,000 tubes and had never known one to explode. Another remarked that in each of the *two* cases that had come to his notice some metallic object had touched the tube and caused the collapse.

Of the several hundred tubes used or tested by the author none "exploded," with one exception. On the evening of December 14, 1900, some observations were being made with seven physicians present in my office. A number of tubes had been got out and were scattered around in different places. Tubes are habitually laid upon tables, chairs, glass plates, and non-metallic surfaces without injury. Two large tubes were laid side by side on a chair. Each was wrapped in tissue-paper. Their walls were in contact with only the thickness of the paper between. Wishing to lay aside a long brass rod and forgetting in the darkness that tubes were under the loose tissue-paper, I laid the rod on the chair in such a way that it lightly touched one of the tubes. The report that followed was as loud as that of a large fire-cracker. The tube *collapsed*, rather than exploded; and this is what we should expect, since the external atmospheric pressure is immensely greater than the internal pressure. The tissue-paper was not blown outward. The adjacent tube was not injured in the least. On removing the covering we found the bulb of the tube shattered into minute fragments, the only pieces of glass of any size being the terminals. Evidence of sudden force of a collapsing nature was shown in the electrodes. Both the rods were twisted, and the anode and cathode were doubled upon themselves. The anode bore many small dents as if from pointed fragments of glass. The tissue-paper under the tube was sharply cut with a myriad of small slashes. This is the author's only personal knowledge of an "exploding" tube.

Connecting Wires.—Do not connect the tube to the terminals of electrical apparatus with conducting wires which are much longer than needed for the given distance. Do not let them sag near other objects. Have several pairs of wires of different lengths. Beautiful flexible cords with silk-covered insulation are supplied by dealers. Almost any copper wire, such as is used for ordinary batteries, will serve to connect tubes. The wire should not be too fine or too heavy. Extremely heavy insulation offers no advantage, because terminal contacts are usually uninsulated. With some forms of apparatus a wire stiff enough to retain the shape to which it is bent is preferable to a flexible cord.

It is essential to have these cords quite widely separated, and for this purpose a vulcanite or wood cross-bar *spreader* may be attached to the tube-holder. Those who have old holders without this device can easily make one. Get a wooden doweling rod three feet long and about five-sixteenths of an inch in diameter. Bore a hole of the same size through a convenient part of the tube-holder. Fix a screw-eye in each end of the wooden stick. For use insert the stick through the hole so that one-half will extend on each side of the tube, and parallel with it. Thread the wires from the electrical terminals through the screw-eyes of this rod before connecting them to the terminals of the Crookes' tube. The wires will then be kept widely apart during use. When disconnected the rod can be slipped out of the tube-holder or can be fastened in it permanently if desired. If a wire is carried from apparatus to an adjoining room or comes in contact with anything but air, it should be then heavily insulated so that none of the current will leak off. With a large static current the avoidance of leakage is a question of correct control of technic rather than direct insulation of wires.

CHAPTER VIII

POSTURING AND EXPOSING APPLIANCES

Tube-Holders. Plate-Holders. Film Protector. Examining Tables and Stands. Exposing Board. Body-Holder. Ophthalmic Head-Rest. Secondary Diffused Rays. How to Exclude Them. Metallic Backing to Plates. Diaphragm and Window. Lead Box for Sharpening Exposures.

Standard posturing appliances are essential to standard radiography. These mechanical appliances must cover means of holding the Crookes tube, the photographic plate, and the part (or the whole) of the patient. Without convenient devices for these purposes accurate and scientific radiography is out of the question. Certain accessory appliances also become important in special work, stereoscopic exposures, the rheotome method, and various localizing processes. Localizers are treated in another chapter, but tube-, plate-, and part-holders will be studied here. The first consideration is something to hold and "posture" the X-ray tube.

Tube-Holders.—Lack of a good tube-holder (or several of them) is one of the most annoying inconveniences of the beginner. It is the function of a proper tube-holder to *hold* the tube exactly where the operator needs to place it with reference to the patient, and to do it *conveniently* and with a total *absence of vibration* during work. The device is rare that will do this. Many of the small independent tube-holders in the market are lacking in some one or more of the qualities of a proper article. If they may serve in other ways they lack rigidity, and are so easily set shaking that they blur the definition of pictures which would otherwise be sharp and clear.

The basis of a tube-holder is a wooden clamp with a cork-lined grip mounted on a wooden post which may be one, two, or even three, feet long. If this is a long thin stick of springy wood it is not rigid enough for the purpose. No part of a tube-holder should be "springy." The tube must be as immovable as a camera during an exposure, and a holder that is easily affected by jarring impulses should not be used.

The primary clamp which holds the tube needs something to carry it to different positions, heights, angles, and relations to the patient, and for this purpose it is mounted on a jointed stand. Stands vary from mere toys to scientific and costly apparatus. The supply in the ready market is limited. Nearly all fine and special appliances are made only to order. They are divided into two classes—independent, and those attached to exposing tables. The independent tube-holder is portable and can be used with any exposing apparatus. It can stand on the floor or on the table near the patient. It can have a tall or short telescoping rod of metal or wood rising from a firm base; or it can be a frame, or upright closet, in which the tube is kept from dust and breakage when not in use.

The character of your X-ray work decides the kind of tube-holder you need. For a wide range of general work a universal holder is required, and as no one holder will be satisfying under all circumstances the expert will have a universal independent holder; and various special stands or an exposing couch with holder device attached.

Attached tube-holders are most convenient for difficult radiography. A bar supported on fixed uprights acts as a tube-carrier laterally or longitudinally along an X-ray examining table; or, a frame holding the photographic plate may have a side arm and runner to carry a tube-clamp. Arm-rests, leg-rests, knee-supports, head-rests for eye cases, standing-frames, adjustable-shelves, and so on up to full-length operating tables, all are made with attached tube-holders for adjusting the focus to any position under or over, behind or in front, of a patient, and at any desired angle. They possess the advantage over separate holders that, when once in position, any necessary shifting of the table carries with it the tube-fixture and avoids losing the focus adjustment, an important matter when much work is done.

For demonstration work and for the special needs of a practice limited to routine lines the operator will soon find out what suits him best, and can then have a tube-holder made according to his individual needs. One of the best combined stands and tube-holders for arm and leg work is made as follows: A stout upright rod of metal tubing stands on the floor on a firm base. On this post an adjustable collar clamps at any desired height and supports the device which carries the tube. The clutch grips the tube by a spring pressure instead of the usual set-screw. The tube can be turned on both its axes and shifted by movable arms to any situation needed. A small shelf can now be clamped on the post at any level to suit the part of the patient, arm, leg, etc. This shelf works on a ball-and-socket joint adapting it to all positions, and has holes one-inch apart over its extent. Spring-clip pegs with straps fit these holes and permit strapping the part steadily in place during an exposure. The whole appliance has a wide range of utility and is one of the best the author has yet seen.

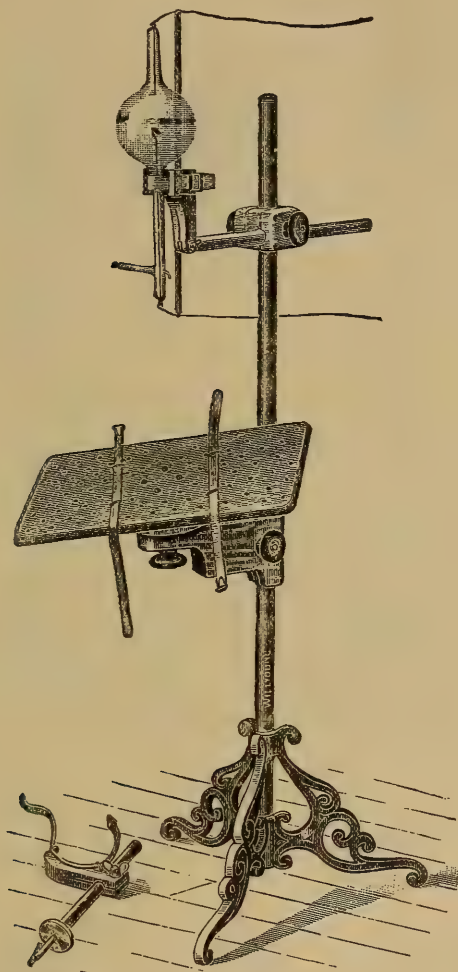


FIG. 1.—Adjustable standard with tube-holder and shelf for exposure of extremities.

Instead of illustrating all varieties of tube-holders here, the reader will find many of them included in other illustrations of the book. For instance, an upright "tube-closet" is pictured with the "Skiameter"; a Davidson cross-bar marked with centimetre scale and containing spirit-level is shown on his localizer apparatus; the tube-carrier for head-rest in radiography of the eye appears in another place: side arms on various tables are shown: several independent tube-holders enter into selected photographs illustrating technique in both the surgical and medical sections of this work, and by noting the special features of each, the reader will gain a general knowledge

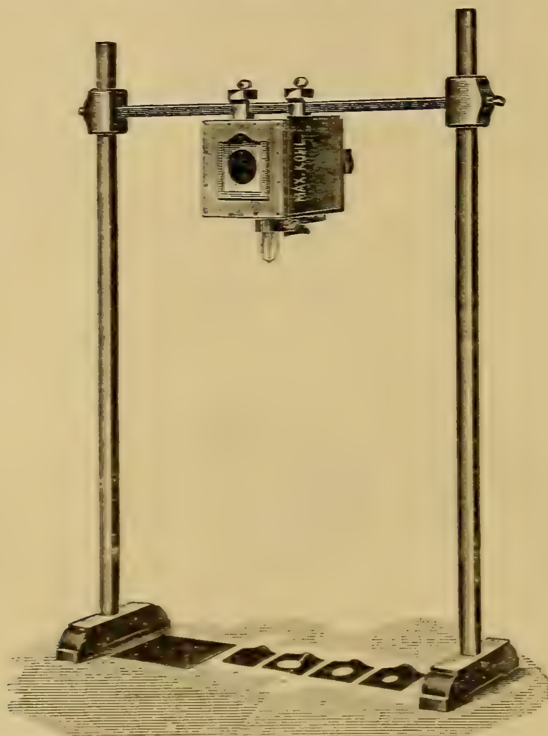


FIG. 2.—Dr. Levy-Dorn's "Protection Box" tube-holder with series of six lead diaphrams of assorted sizes. It is adjustable on the standard, and when the tube is used in the box it excludes all general light and allows only the X-rays that come through the window of the selected diaphragm to reach the patient. It is especially designed to avoid ill-effects from exposures to X-rays. It is lined with lead and is also fitted with an aluminum screen. In addition to the protection of patients it is also useful to regular workers in this field who are exposed several hours daily. Such a box will preserve their hands and eyes from injury.

of what actual experts use in actual practice. Avoid a shaky tube-holder, but a good device can be simple and moderate in cost.

Plate-Holders.—In the simplest form of X-ray work the plate is exposed in the envelopes now furnished by all dealers, but the use of photographic screens necessitates modification of the regular holder in common use by camera artists. Dealers supply them to order. They are so made as to take several sizes of plates. In ordering state the largest size. The plate must be changed in the dark room. No envelope is used when the plate is placed in this holder. It also acts as a support, preventing breakage. It can be used in plain exposures if preferred to the paper envelopes, but is designed to permit the employment of one or two intensifying screens against which the film is placed and the holder closed. When closed it is light-proof till opened. All experts will find a good plate-holder invaluable.

Instead of using a metal backing for plates wrapped in paper envelopes or enclosed in the ordinary plate-holder, with its frame of wood, the combined objects may be obtained by making a *metallic plate-holder*. This will not only reinforce the exposure, but will exclude diffused secondary X-radiations. Simply make two rims of brass, one to fit snugly inside the other, and of a size to receive the photographic plate. Hinge them at the back and have them clamp shut in front. Over the front solder a very thin sheet of aluminum. Upon the back solder a thick sheet of brass. Line the largest rim on the inside with a strip of cloth so that when the now complete box is closed it will exclude all light. When the plate is inside this box

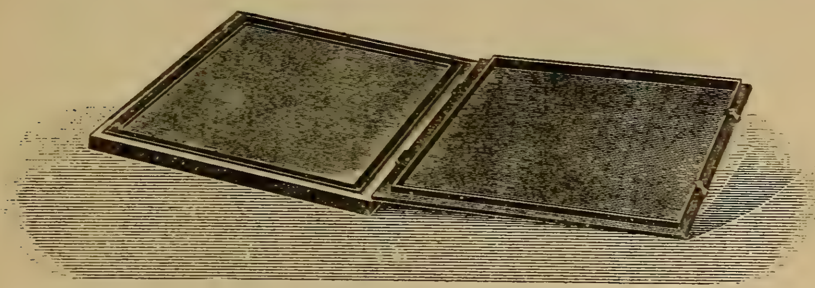


Fig. 3.—Shallow metallic box for holding plates as described in text with exclusion of diffused secondary X-rays.

it will be protected from breakage by pressure, from light, from diffused rays, and from the perspiration of the body. It will permit the use of a photographic screen. It will be thin, strong, and convenient, and, if made to take a large-sized plate, will also permit the use of all smaller sizes. The advantage of the metallic back of the plate-holder will be explained in another section.

Exposing Plate-Holder for Erect Positions of Patient.—To make the device employed by Von Ziemssen and Rieder in their *one-second* radiographs of the thorax (and which is useful from the feet to the head), proceed as follows: In a convenient part of the operating-room erect two narrow vertical runners sixteen inches apart, in the grooves of which will slide like a sledge the feet of a wooden frame with a front board 14 × 17 inches in size. On this front board tack a plate of smooth sheet-brass one-sixteenth of an inch thick to serve as a metallic backing for all plates exposed. On each side of the movable frame arrange a strap or means of steadying the part exposed in close contact with the film. On each side of the front of this frame arrange an adjustable piece to retain any size plate from 14 × 17 down to 8 × 10, with a narrow ledge below to complete the "holder." From the centre of the plate-carrier run a cord over a pulley in the top cross-bar of the apparatus with a counterpoise weight at the end so as to balance the exposing frame at any desired height to which it

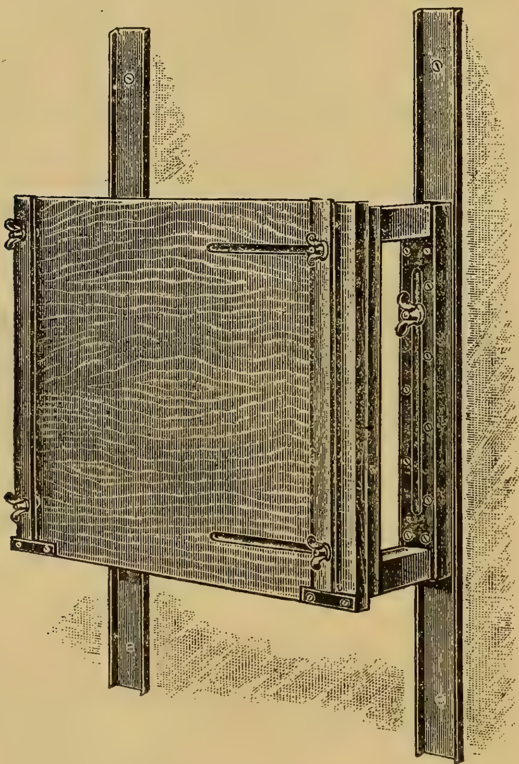


FIG. 4.—Sliding frame plate-holder for exposures of the thorax by Von Ziemssen's method described in text.

is moved. Add a set-screw to fix it in position when localized for the patient. From the most convenient side of the frame build out a permanent rigid arm for a tube-holder which will retain a fixed focus of the anode at right-angles with the exact centre of the frame and twenty inches from the plate, so that all plates exposed will be automatically centred without further detail. The frame and tube-holder being connected the tube will accompany all adjustments of the frame to suit the height of different patients, and of any part of the body which it is desired to radiograph in the erect position. It will be found of great practical convenience, not less for the foot and leg than for the trunk. Sitting or standing patients can be posed in many convenient ways with this device.

Protection of Film from Heat and Perspiration of Patient.—When heavy parts are to be subjected to a long exposure during any season of the year when perspiration or the heat of the body would affect the film without protection, we may require something more than the ordinary envelope-wrapper. The use of a plate-holder obviates injury to the film by perspiration or heat, but when no plate-holder is used a piece of fine thin oiled silk, laid smoothly over the envelope, will keep out moisture. Both heat and moisture are preferably excluded by means of a very thin sheet of transparent celluloid, sold by art supply stores, and every operator should procure such a sheet. It should not be used when not needed to protect the film from heat or moisture, as every layer of material which separates the object from the film adds to the magnification of the shadow.

Examination Tables for X-ray Work.—The ideal table for this purpose is far removed from the surgeon's operating table in construction. It should be light, yet firm and strong; movable when desired, yet

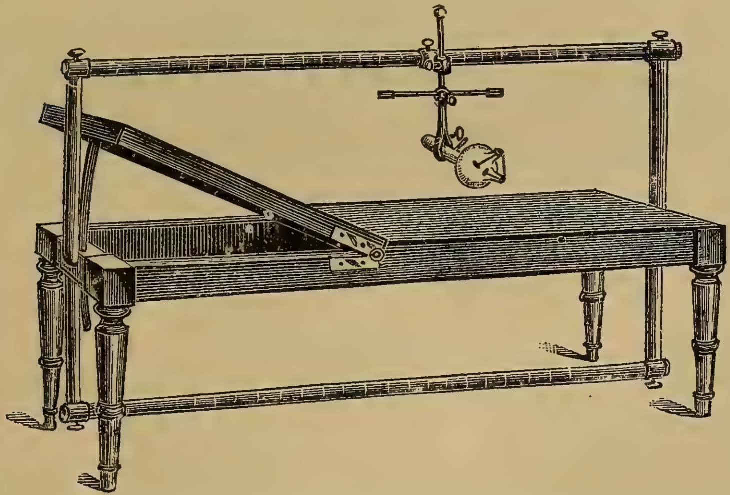


FIG. 5.—An X-ray examination table showing longitudinal tube-carriers above and below the patient. The jointed end can be raised or lowered to suit, the top is a thin, hard fibre which is transparent to the rays. Underneath and not seen in the cut is a traveling plate-holder for exposures with tube above patient.

steady during use; adjustable to all needed positions; should have a transparent top, removable in sections; should allow the ready placing and changing of plates; should carry its own tube-holder adaptable to all positions over and under the patient: should be compact and no larger than necessary; should have accessory blocks, frames, and clamps for immobilizing any part of a patient during exposure; and the top should be made to tilt or swing on a pivot by releasing mechanisms for this purpose. Couches, canvas-covered litters, plain tables, folding-chairs, and a number of special tables have been devised and employed for X-ray work, but there is still some room for improvement. If cost did not stand in the way, however, the ideal table could no doubt be made to order at the present time for anyone desiring it. A table of some kind is indispensable.

While operating tables and tube-holders are made in quite a variety, yet most of them contemplate all other positions of the tube save the important and often indispensable one of underneath the

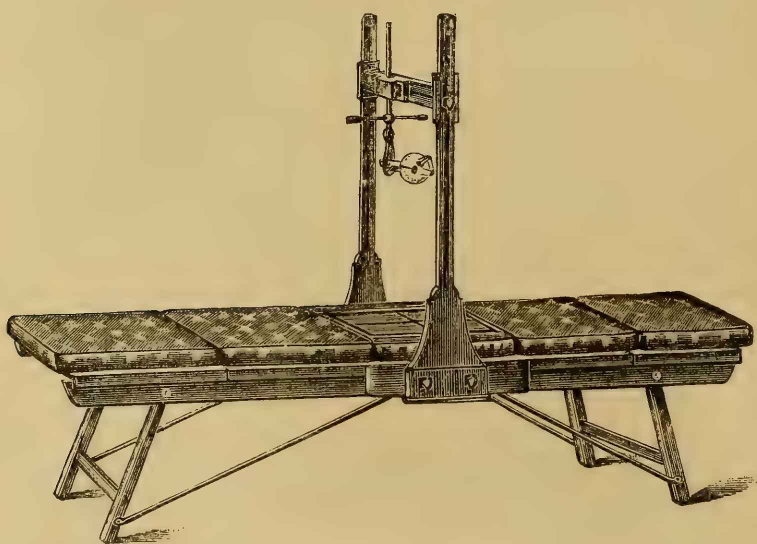


FIG. 6.—Example of X-ray examination table with sliding tube-carrier and cross-bar. The top is removable in sections, and the square seen under the tube and marked in quadrants can be shifted to center the plate in any other desired situation on the table. The millimetre scale on the cross-bar and the sliding adjustments of the tube-holder assist accurate work. It is one of the best and simplest tables made.

patient. Not only is it often important to place cases in the recumbent position and examine them with the fluoroscope, but it is absolutely essential to do so in the case of invalids whose disease or injury, or the state of anæsthesia, compels recumbency. An operator must be able to lean comfortably over the patient and use the fluoroscope in the axis of the rays. This requires a table lower than the usual surgical table, and it also requires what is lacking in almost all tables, viz.:

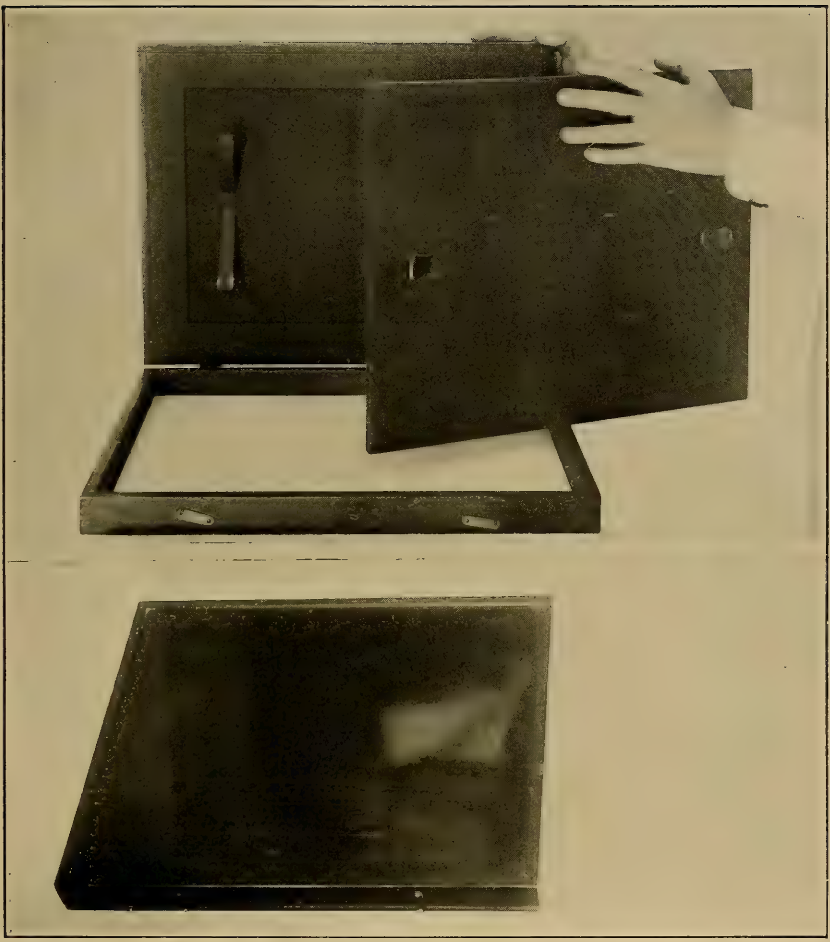


PLATE 9.—Author's Special Plate-holder. The upper figure shows the open box with white photographic screen laid in. Place the film down on this. Then lay over the plate the base which in the picture is seen steadied by the hand. Then close down the top and clamp it fast. The spring seen under the cover is one of a pair which press and hold the plate firmly against the thin ebonite sheet of the front. The lower figure shows the plate-holder closed and ebonite front uppermost. When placed in position on the operating-table lay the part on it and make the exposure as usual. Plates cannot break in this holder. It will receive any size from 4 x 5 up to 14 x 17.

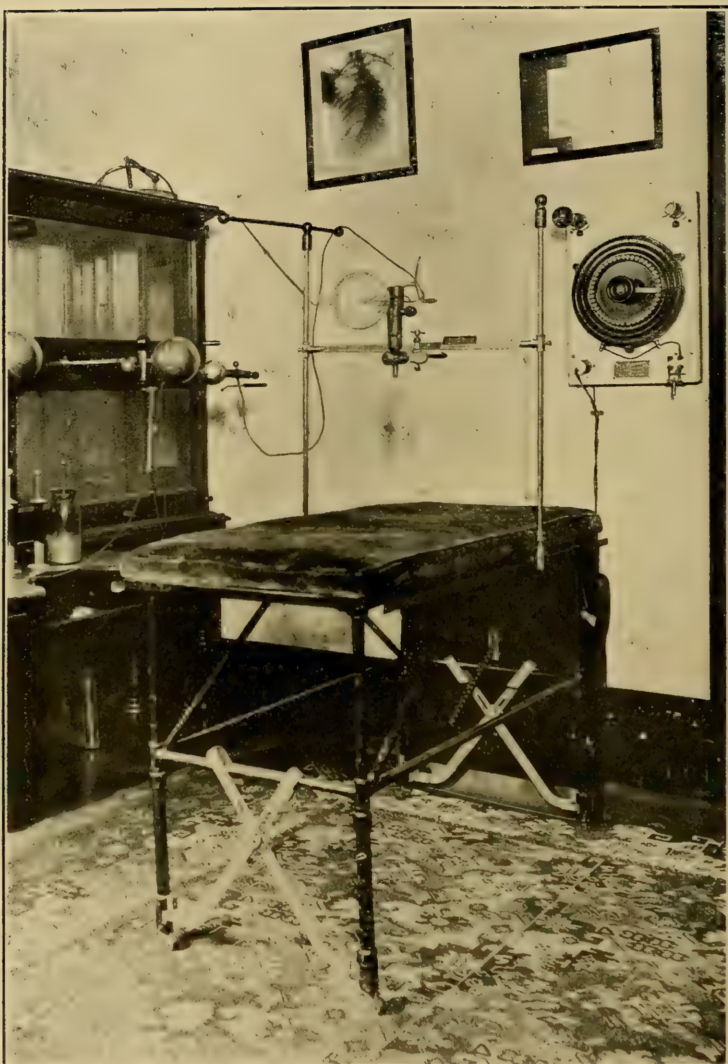


PLATE 10.—A Table with Cross-bar Tube-carrier and Scale. On the left pillar is a vulcanite spreader supporting the wires from machine. This plate and figures suffice to teach the general designs and accessories of useful examination tables, and these are modified in various ways to suit individual wants.

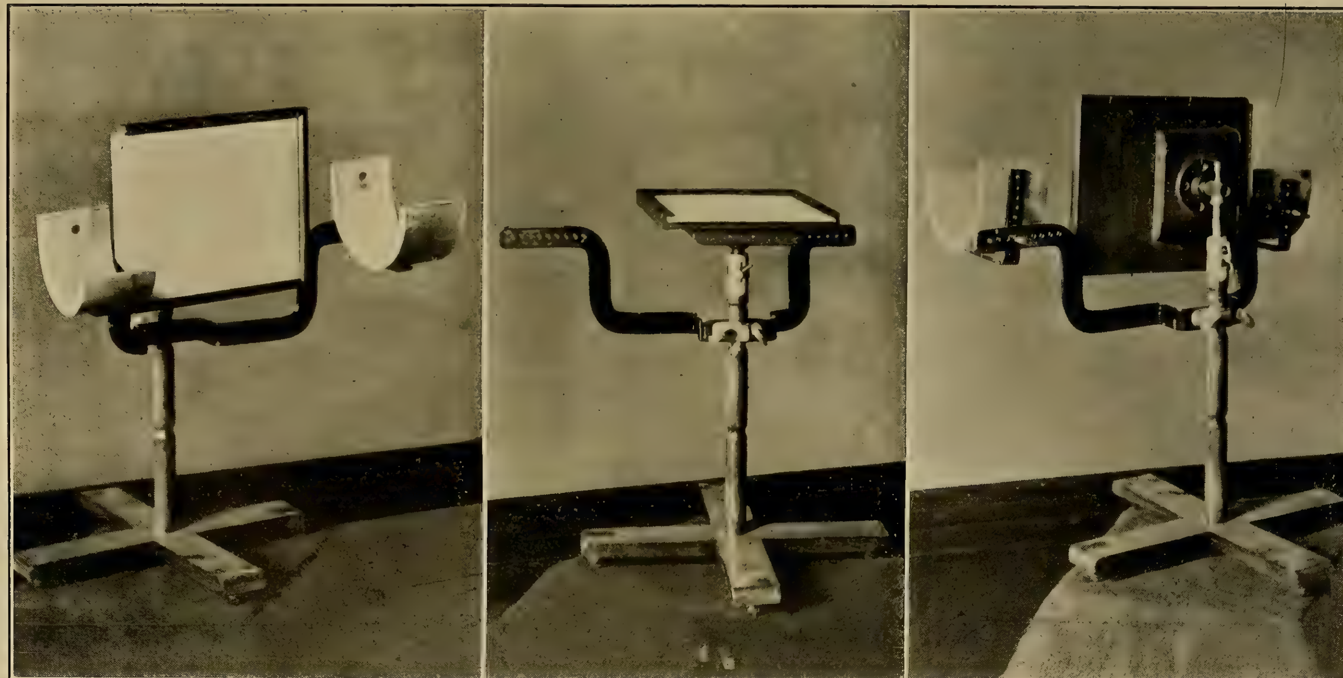


PLATE 11.—Stands for Leg and Arm Radiography. The right and left figures show back and front of leg-stand. Place the plate in the frame as shown; adjust the movable leg-holders to bring the part in relation to the plate and secure position with strap if needed. Particularly suited to lateral postures of a partly flexed knee. The central stand shows the same with leg attachments removed and in position for arm. The table top can be raised to any desired level. In subsequent plates the technic will be shown with patient.

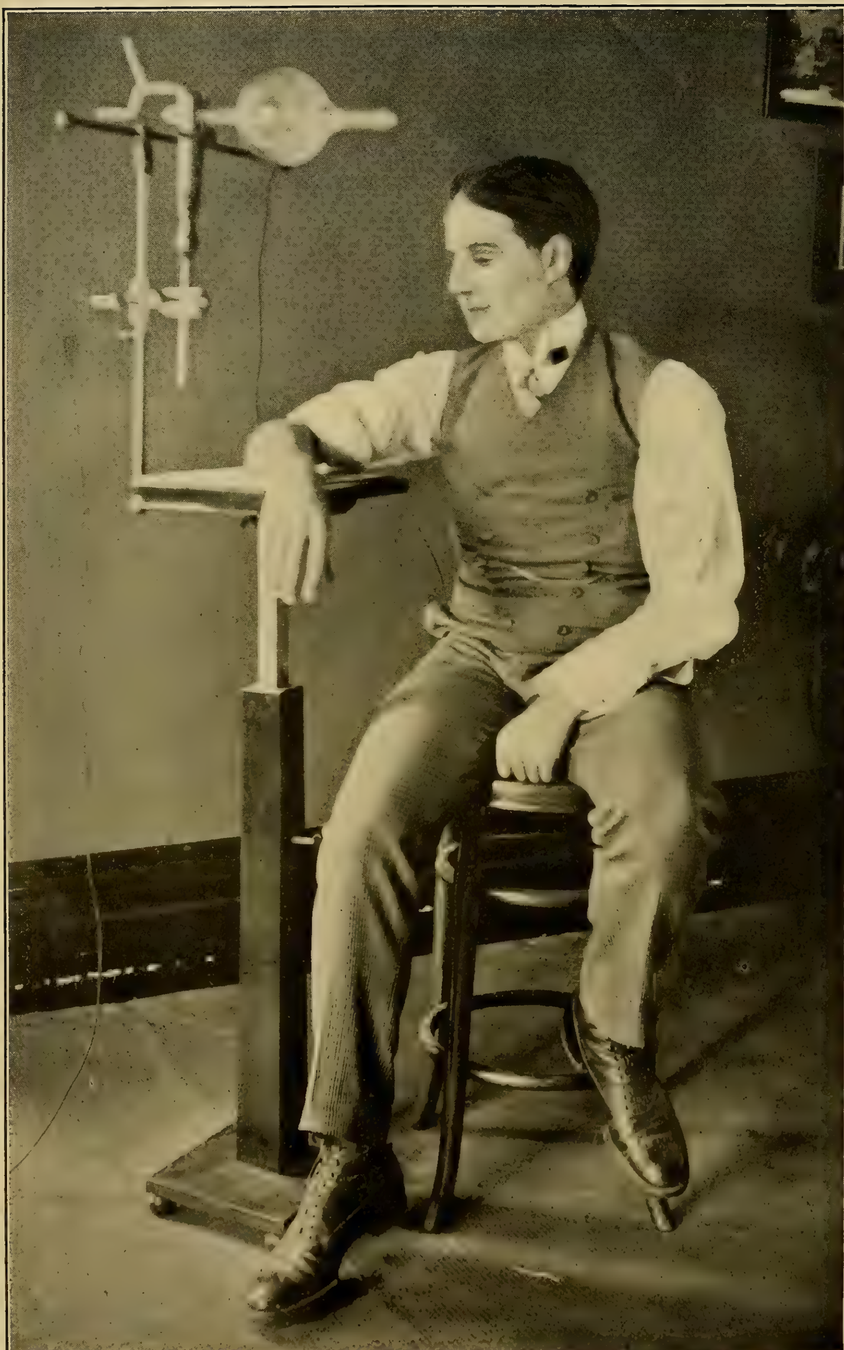


PLATE 12.—Exposure of Arm with stand shown in previous plate. The tube and table supporting the arm can be raised and lowered as needed. Centre the anode, lay the photographic plate on the top, put the field of the part in position, and make the exposure. When once centred over the table the tube can remain ready for any number of subsequent exposures with axis effects.

a tube-holder which is fastened to the table, and is adjustable in any desired situation *below* the patient.

A canvas-covered stretcher built on a frame so that the top is pivoted and can be rotated from side to side and tilted up or down in the long axis is useful. The frame can be placed upon large, easy-rolling wheels, so that it can be moved readily, and should have a leg attached which can be let down to the floor when desired to steady it and prevent accidental movements when fixation is wished.

If a dependent tube-holder with sliding arms is constructed under the table, so that the tube can be shifted along its entire length with-

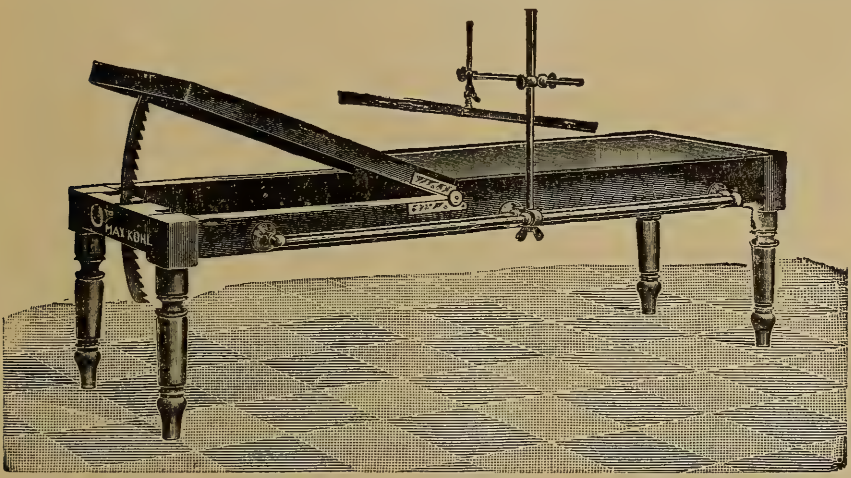


FIG 7.—X-ray examination table with holder for light-tight case containing the plate and intensifying screens. This holder is so constructed that the case with plate for radiograph can be placed in position either under or over the table.

out deranging the wires connecting it with the current, the stretcher will be complete. As men differ in height the individual having such a stretcher made for his own use should place a fluoroscope to his eyes and determine by actual test at what height from the floor he can comfortably bend over all parts of a recumbent patient, and secure a vertical position of the instrument with the screen horizontal to the path of the rays.

Exposing Board.—Not only is it more or less difficult to secure good pictures of the pelvis and hip-joint, but it is often difficult to pose the parts so that both sides of the median line, or both hips, or the necks of both femurs, or whatever two parts it is desired to compare, hold the same relation to the rays and to the axis of the body. To facilitate posing both lower extremities parallel to each other or in equal relations to the spine and plate, take a piece of plain pine board two feet wide and three feet long. At the lower end attach by a hinge-joint on each side of the centre a strip of the same board four feet long and eight inches wide at the top, and narrowing to five inches at the feet. Make the hinge-joint connecting the two leg-pieces with the body-board work laterally, so that when the leg-pieces are brought together in the median line the crack between them will continue a vertical line drawn on the centre of the body-board. Have each leg-piece separate equally from the median line by means of an adjusting cross-bar at the foot. Paint a plain black line down the perpendicular axis of the body-board and down the vertical axis of each leg-piece. Paint cross lines at right angles to correspond to the approximate levels of the shoulder-joint, the elbows, knees, and ankles, so as to indicate right-angled positions of the parts when the axis of the spine of the patient is on the median line of the board. Draw a definite cross line to indicate a line between the anterior superior spines of the ilium, and place the patient always in correspondence *with this mark and with the vertical axis.*

Next bore a series of three-eighth inch round holes, an inch apart, down both sides of the body-board equidistant from the middle axis, so as to bound the trunk of an ordinary person. Duplicate the series at lesser and greater distances from the axis so as to fit both thin and corpulent subjects. Run parallel series of similar holes in relation to the legs down the leg-pieces, and in relation to the arms across the body-board, so that the arms can be mutually posed at any angle from the body. Make a set of thirty round and straight wooden pegs to fit these holes firmly and stand up out of them five inches clear.

We now have a means of comparing the normal side with the injured or diseased side with absolute equality of relation to the X-rays.

To use the exposing board place it on top of the regular operating table and lay the patient on it so that the trunk fits snugly between two rows of pegs placed at intervals of a few inches down the line conforming to the previously measured width of the body of the given case. The axis of the spine will then fall on the axis of the board without other care. If the case is a hip-joint decide on the exact posture in which it is desired to show the injured or diseased side. If the neck of the femur is to be shown in its long axis fix the leg accordingly. By rows of pegs on both sides of the leg delimit its position and strap it fast to the leg-piece. It will now be immobilized at the desired angle for the exposure. On the duplicate leg-piece peg and strap the normal leg in the same manner. Separate the two legs equidistant from the median line so that the angle of the normal leg conforms to the adjustment of the other, and secure them in this situation by the cross piece at the foot of the appliance.

Or, if the arms or shoulders are to be compared, peg the two at equal angles from the trunk and strap them in equal positions on the same principle.

Other uses of the board will suggest themselves in a variety of cases. It gives bi-lateral comparisons with the utmost facility and can be easily made. For the exposure on one plate or two separate plates slip the plates under the parts, adjust the tube as indicated, and proceed in the usual manner.

A Body-Holder.—To aid in immobilizing the body of fidgety patients for a radiograph take two flat boards of well-seasoned wood, each twenty-two inches long, fourteen inches wide, and not less than half an inch thick. Join these at an exact right-angle and prevent warping by cross pieces at the ends. Make two belts of firm, thin webbing an inch wide and a yard long. Also two short belts a foot long for small parts. At one end of each sew a neat buckle. In both boards cut two sets of holes through which the belts will pass; one taking them horizontally and one vertically.

The side of this frame affords a support which the operating table lacks, and when placed on the usual table this vertical side can be made right or left as desired by simply turning the frame around. For a horizontal exposure of any part of the trunk of the body in either dorsal or chest position the addition of the frame to the table gives us a handy means of strapping the body so that the part exposed will not move. The frame can be clamped to the table easily, but it will usually be anchored by the weight of the patient. It can also be placed on a stand or laid on the floor or stood on an end. It is equally useful for exposures from above downward and from side to side. For centering the plate directly under the centre of the diagnostic field use the author's "Position Finder," as will be taught later, or employ the ordinary plumb line. Or, use the following:

Block and Pin for Focussing Anode.—An independent and ready position-finder and means of quickly focussing the tube in the exact axis of radiation with the plate at right-angles to avoid distortion is a block and pin. Take a smoothly planed pine block 3 × 3 inches thick and six inches long. Through the centre of the block drill a small hole at exact perpendicular so that it will hold a snug-fitting steel knitting-needle at right-angles to the base.

If a horizontal exposure is to be made place the tube in approximate position and start it into action. Then with one hand hold the block against the inner side of the frame so that the pin projects toward the anode from the point which will be the centre of the photographic plate when the exposure is made. With the fluoroscope on the outer side of the frame against the site of the block observe the shadow cast by the pin. Shift either the tube or the frame till the shadow *ceases to be a line* of any length and *becomes a mere round spot,* thus showing that the pin *coincides with the central axis of the rays.* Remove the block, place the plate and patient *over the spot thus marked* and make the exposure. The resulting picture will show a correct and non-distorted shadow of the parts under the axis of the rays. The simplicity of thus securing accuracy commends it, and a single test will demonstrate that a plumb line cannot be used to equal advantage. For vertical exposures sight the pin as described in section on author's regular Position Finder.

Effects of Secondary X-Rays during Exposures.—While the many published theories regarding the nature and action of X-rays would give no help to any surgeon in taking an X-ray picture, yet there are a few facts to be culled from scientific reports which have an every-day bearing on exposures for radiographs, and which all ought to know. Among these useful facts are the following:

1. X-rays are produced when the cathode stream strikes an obstacle. A dense metal is a greater obstacle than the glass wall of a tube, and, therefore, reflects more X-rays. Hence an artificial obstacle is placed in the tube to be struck by the cathode stream. As the electric-current generates heat the metal must not only be dense, but have a high melting capacity. Platinum is the most practical metal possessing these qualities, though osmium is better. The extreme rarity of osmium prevents its use except by a few. Makers have determined by many tests the best situation and angle in which to place the platinum anode, sometimes called "anti-cathode," or "reflector."

2. X-rays are also produced at the same time that the anode is active from its entire front surface and from a part of the walls of the tube, but the chief rays arise only from the small area on the anode directly struck by the long-axis point of the cathode stream. All others are lesser rays and impair rather than help our work.

3. X-rays themselves in turn send out new X-rays when they strike other bodies, even the air; so that if direct rays are cut off from a screen by a metal barrier in front of it some rays will appear to reach it from the sides, and it will still feebly fluoresce. This effect is not due to any bending of the rays, for they do not bend, but to the fact that while the original rays "radiate" from the anode in rectilinear lines straight from the focus like the spokes of half a wheel, the secondary crop of feebler X-rays emanating from collisions with air-particles are sent out in all directions instead of in

radii only. These are the rays that need restraint lest they blur effects and dull the definition on the plate.

4. While the popular supposition is that in X-ray work we have to deal with shadows cast by a point of light, this is only in a measure true of the central rays of maximum efficiency, and the presence of lesser X-rays so enlarges the theoretical "point" of desired focus that if our eyes were directly sensitive to the rays a tube would appear, not as the ideal shadow-casting point, but rather *like a lamp in a smoke-filled room.* During long exposures of a plate these feebler rays have a chance to impress the effect of a penumbra around the borders of the net shadow from the real focus-point, while a short exposure more nearly escapes their action, and hence gives a sharper definition, as is well known.

5. Therefore the radiations from a tube are *mixed*, and the rays resulting from minor or secondary collisions are of different degrees of penetrating intensity, or so-called "absorbability."

The practical bearing of these few facts, for which our authority is Roentgen himself, will be appreciated by every surgeon who aims to advance his work and to properly interpret his results. The next section will speak of excluding secondary rays from the negative.

A Metal Background for Plates.—Among the various causes of blurred and indistinct negatives, especially when a low tube requires a long exposure, has been fluorescence of diffused rays around the plate reacting on the glass and creating a partial image from the sides. On the other hand, it has been shown that if the rays are checked at the back of the plate the fluorescence is intensified so that a more perfect image is secured in less time than from unchecked rays.

In 1898 it was quite common for expert operators to lay the plate upon a thick piece of plate-glass or to back it with a sheet of lead. Buquet, in 1897, reported experiments in radiographing a watch on a plate half of which was backed with lead and half not. The exposure was two minutes. The difference in sharpness of the halves of the picture was very marked. The part on the half backed by a cut-off of the rays gave sharp definition, while the other half was hazy and without detail. Many similar tests show that by arresting the actinic action of the rays we secure the effect of an increase of light, and the result is a better picture with a shorter exposure. Under ordinary circumstances, with improved apparatus, the average operator may feel that his results are good enough, and that a metal backing is not needed with a fine tube and a short exposure. Nevertheless, with any or the best tubes and with any length of exposure, the cut-out plate is a benefit to the negative. But even heavy glass is fragile and does not arrest the rays enough; lead bends and offers no advantage over brass. Therefore a base-plate of flat brass three-sixteenths of an inch thick is better than either glass or lead, for it is opaque enough and is a firm support on which a negative can rest without danger of breakage from the weight of the body. As the base of my " Position Finder " makes an ideal backing of this kind for arresting and intensifying the actinic action upon the film, thus serving two purposes at once, a description of it need not be repeated here. But any stout plate of metal will do. The routine use of such a backing is advisable and advantageous.

Combined Photographic Screen and Brass Plate.—An expert writes as follows: " The difference, if we use the tungstate of calcium screen over the dry plate resting on some *metallic* support instead of wood, is marvellous, and the results are really beautiful. In this way we both increase the sensitiveness of the film and accumulate more rays upon it, and reduce the time of the exposure. I have only one screen, 8 × 10 inches in size, and use the same in all cases of bone injuries, bone diseases, foreign bodies imbedded deep in soft tissues, fractures, dislocations, skiagraphy of the head, hip, knee, etc. The results obtained are most gratifying, and are very practical." The ordinary paper envelopes are not convenient for this work. But with a deep plate-holder, such as was made for me in August, 1896, taking readily my 14 × 17 photographic screen, any size plate up to 14 × 17, and the thick brass base of my position finder, at the same time, simply closing on them with a clamp, the process is as easy as the making of the usual radiograph. Any operator can succeed with it, as it presents no difficulties whatever. In other sections of this course more will be said on this subject.

The Diaphragm and Window.—Several experimenters, beginning with Leeds and Stokes in March, 1896, have employed a " diaphragm " for sharpening the shadows on X-ray plates. By the latter part of 1898 they had nearly gone out of use. Yet it is claimed that with the improvement in generators and tubes which has displaced the diaphragm it is really needed more than ever, " as a powerfully excited tube gives out X-rays over a greater area than the focus point on the anode." The device can easily be readopted.

One author has described with care and illustrated with cuts his own idea of a glass plate one-half inch thick, a foot square, and fitted into the front of a wooden box holding the tube. In the centre of this plate is a window three inches in diameter. Other plates have smaller windows for variations in the size needed in a given case.

He prefers glass to the metal plates used by other operators, and if the metal is not grounded his objection is valid.

But without additional detail or new device our X-ray gauge described in another chapter may be grounded and stood in place with the shutters up, and makes a practical and simple diaphragm for horizontal work.

As the object is to cut off all rays around the active field so as to lessen the *penumbra*, place the gauge between the tube and the fluoroscope or photographic plate, whichever is being used, and adjust it so that the axis of the rays passes through the centre of the window. Regulate its distance from the tube by the area of the field to be covered by the rays. If a larger or smaller window is desired by any operator a gauge to suit can easily be made.

Various experimenters often desire to employ exceptional devices to serve peculiar ends, and as even methodical operators here and there may find a home-made diaphragm useful, directions for constructing it will be found in the following letter from a prominent electrician:

"The employment of metallic diaphragms in radiographic work is objectionable on account of their conducting properties and their tendency to attract the high-tension discharge away from the tube. Very thick glass has been used, but such diaphragms are expensive to make and heavy and cumbersome to handle.

"Chinese, or the best grade of English, vermilion is nearly as opaque to X-rays as a silver coin when of the same thickness in a pure mass. For use mix it with a solution of shellac in grain alcohol, employing only sufficient shellac to make the vermilion hard and solid when dry, but not enough to impart any glaze to the dry surface. Make the mixture about the consistency of ordinary thick paint.

"Now take two pieces of firm cardboard of any desired size, say sixteen inches square, and cut in both a central circular window two and one-half inches in diameter. Give each cardboard a coat of the vermilion varnish on both sides, and when dry repeat. Dry and repeat again. Then freshly coat one side of each board and at once stick the two together, and under flat pressure dry them for several days. Then trim neatly, cover with plain protecting paper, and it is done. The combined thickness of the coats of vermilion is sufficiently opaque for ordinary radiographic work at exposure distances. I use a high-frequency coil which produces a strong spark-stream, and the discharge shows no tendency to leak across or through the diaphragm. It is cheap and easy to make, very light and handy to use, and nearly as strong as a metal screen." (Andrews.)

Lead-Covered Box with Diaphragm for Excluding Diffused X-Rays in Radiography.—Take the top and two ends of a plain pine-box.

Make top twenty inches square. Make the ends fifteen inches high. Over the outside of all tack a sheet of lead one-sixteenth of an inch thick. Reinforce the frame at the corners so it will be strong and secure. In the centre of the top cut a round window four inches in diameter. This completes the essential frame.

Next take four flat squares of heavy sheet lead, 5 × 5, and in each

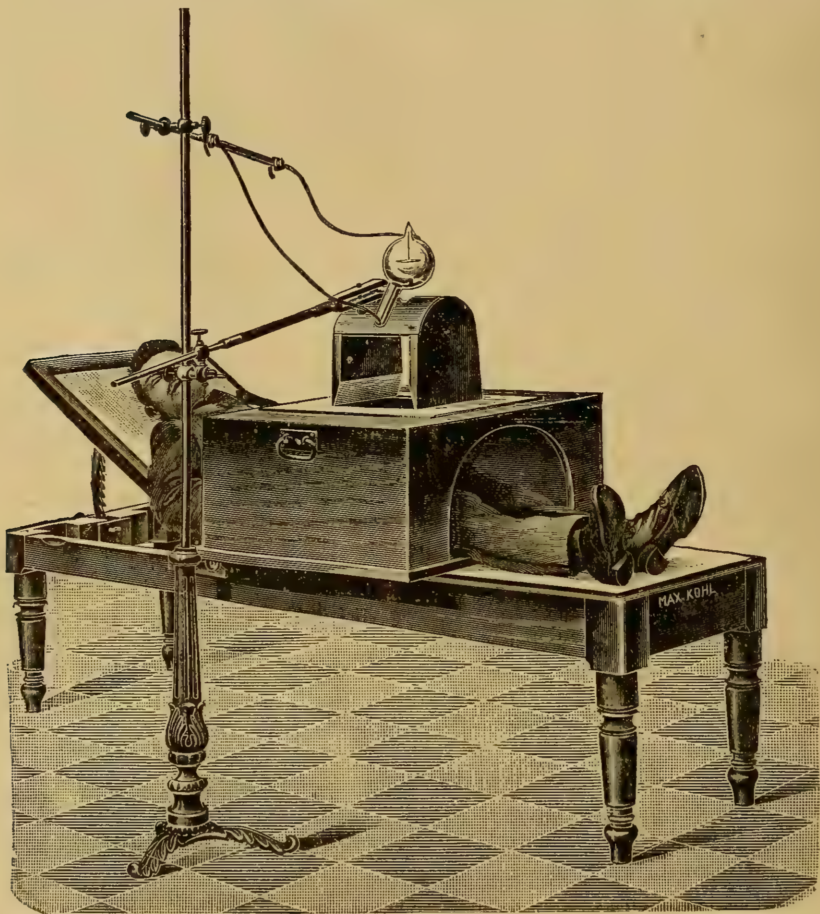


FIG. 8.—Lead-covered box with diaphragm for excluding secondary rays and sharpening exposures.

cut a round window. In use, a selected square (the diaphragm) is to be laid centrally over the window on the top of the frame so as to furnish the proper size of opening for direct rays to reach and cover the plate exposed. Hence the size of the diaphragm window will vary according to the area of the plate used and the height of the anode above the opening. Let the standard distance between the

PLATE 13.—Exposure of Knee with inner side on plate. Tube levelled at twenty inches with axis of rays striking centre of knee and plate. With different adjustments of the curved supports, any part of the leg may be postured at any angle or in extended or partly flexed fixture.

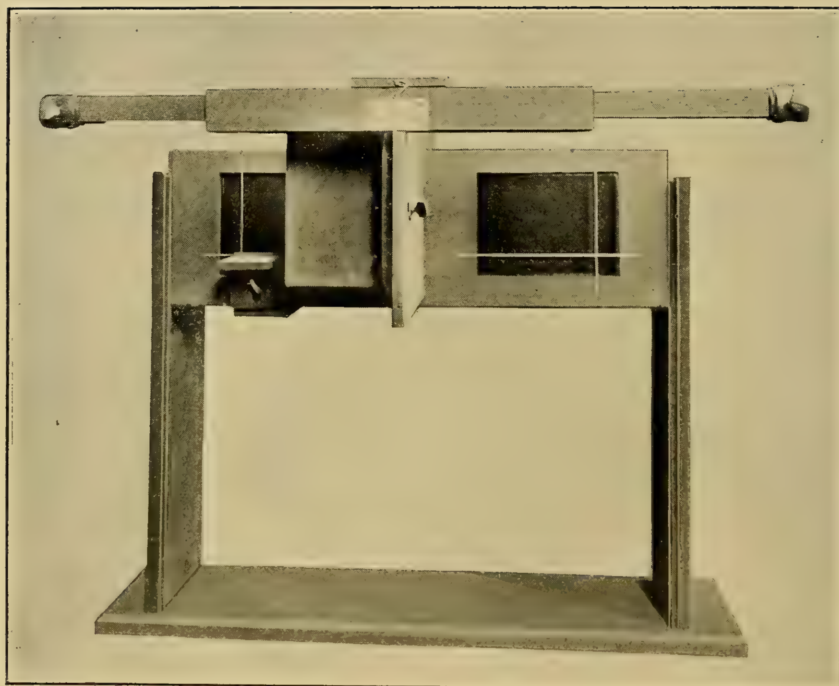


PLATE 14.—Head-rest for Ophthalmic Radiographs. Author's duplicate of Davidson's Head-rest for fixing the plate and head during exposures for localization of foreign body in the eye. To hold the head with absolute fixation while making two radiographs of the eye Davidson devised a head-frame which serves the purpose exactly. It is made stoutly of hard wood. The one in possession of the author is mahogany, and has a right and left side. The photograph shows it very imperfectly. A 5 x 7 plate fits in either side window. A chin-clamp fixes the head immovably in the desired position. This is one of the great advantages of the appliance. A sliding tube-carrier takes a tube in a fixed relation to the eye exposed. A scale on the arm measures the side displacement when stereoscopic radiographic pictures are made, and to facilitate stereoscopic exposures was one of the chief reasons for making the frame. The surgeon dealing with the localization of foreign bodies in the eye will find it indispensable. It may be useful for other head-fixations for radiographs.

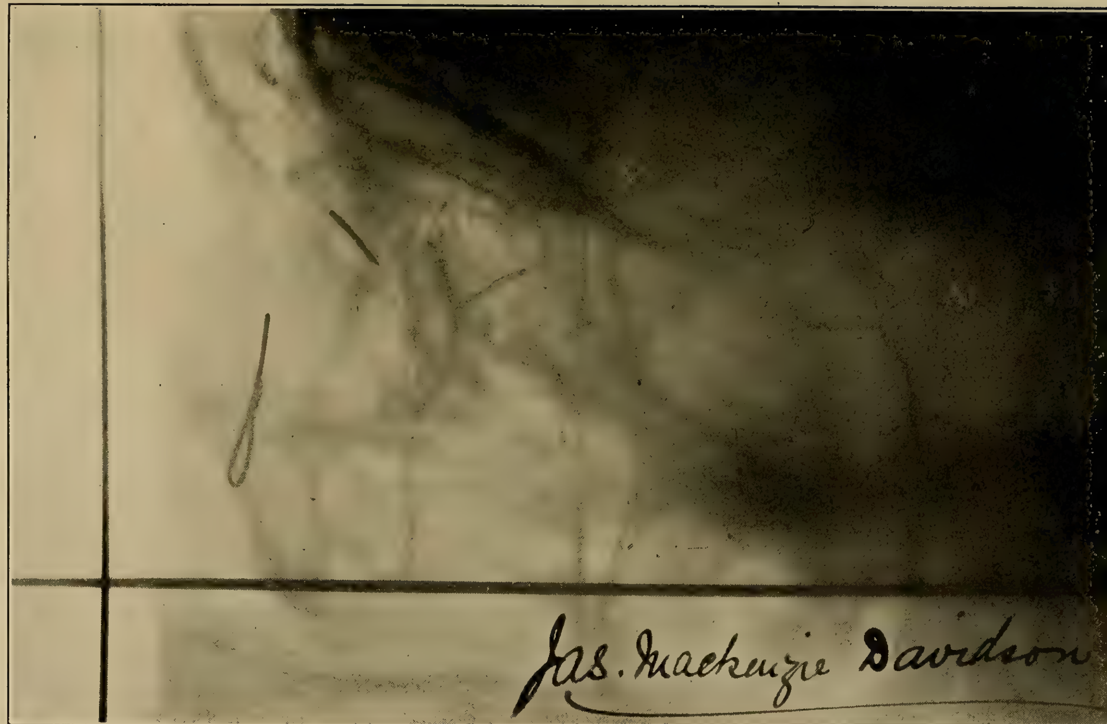


Plate 15.—Example of Stereoscopic Radiograph of piece of steel in eye. The original pair were made by Mr. Davidson with the aid of his Head-rest illustrated in this volume, and the steel was exactly localized by him with his Cross-thread apparatus also illustrated in this volume. The loop is the lead land-mark fixed on the eyelid. The lines of the rods are the means of registering the prints in exact apposition in the stereoscope and are seen in the cut of the Head-rest. The half-tone has lost much of the fine detail, but is instructive.

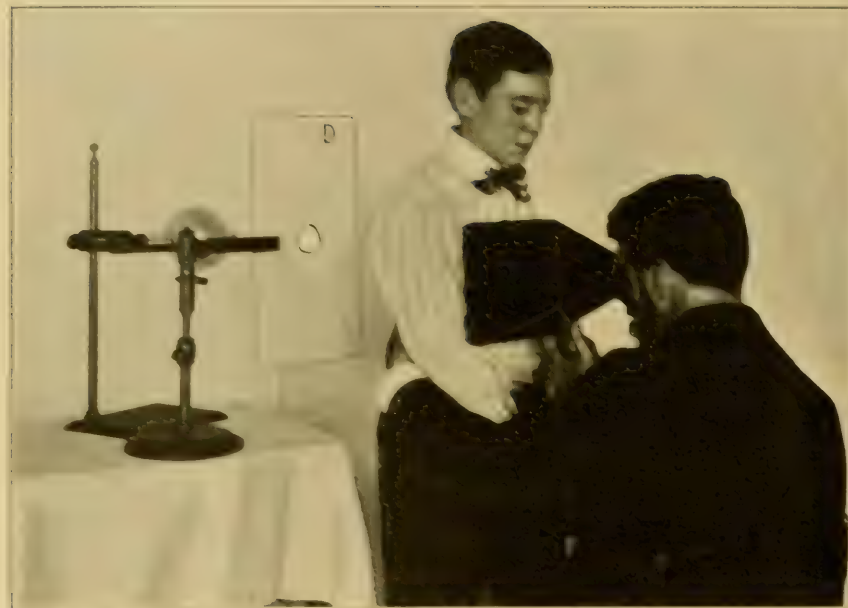


PLATE 16.—Fluoroscopic Inspection with Diaphragm between patient and tube. The Diaphragm partly hides the light of the tube from the eyes, and also cuts off most of the X-rays except those coming through the small window in line with the focus. Note that the examiner's left hand presses the patient up to close contact with the screen, a fundamental need in fluoroscopy. Any tube-holders and support for the diaphragm may be used, and those here shown were selected merely for convenience in making the photograph. The tube and path of rays through the window being fixed, keep the screen in the illuminated field, and shift the parts of the patient successively into the field of the screen. This insures a correct and undistorted view. The picture fairly illustrates a suitable method of inspection of the chest with all factors in relation.

anode and the plate be twenty inches. The frame being fifteen inches high, the opening in the diaphragm upon its top may be five inches from the anode, or can be exactly measured with a rule. Refer to the author's Divergence Chart and note the diameters required to cover the field of such sizes of plates as the operator most uses, and cut them accordingly.

In use, select the square with the window adapted to the size of the given plate, place it in position, and, after adjusting the tube and patient, block up the frame so that the diaphragm will be as close to the wall of the tube as possible without attracting the current. Then make the exposure as usual. The box can be grounded if desired. It is simple, inexpensive, easily handled, and effectively shuts out the secondary rays which tend to blur the lines of a radiograph, particularly with long exposures. The accompanying illustration is taken from a more elaborate box employed in Germany. With distance and window adapted to the area of the lesion the same device may be used instead of a so-called "lead mask" in the exposures of X-ray therapy. By standing it on its side on the edge of a table it can also be used for exposures in the sitting posture.

CHAPTER IX

SCREENS

Photographic Intensifying Screens. Protecting Metallic Screens.

The word "screen" has been commonly applied to the chemically-coated front of the fluoroscope, or the open fluorescing sheet which the X-rays make luminous to the eye; to the similar but differently finished sheet of coated paper made to fluoresce against the photographic film and intensify the actinic action of the rays and shorten exposure-time; and also to various sheets of metal, aluminum, lead, etc., which have been employed to "screen" the patient's tissues from by-effects in therapeutic exposures. The word *screen* does not well fit these different uses, but none other has been coined. We will now take up the different forms of screens in regular order and study them. The fluoroscope will be considered in another chapter.

Photographic Screens.—On or about April 3, 1896, the author saw for the first time a negative, part of which had been reinforced with a tungstate of calcium screen. It plainly showed the more rapid activity of the rays on the covered portion of the plate, and with the feeble apparatus then at the command of the operator he believed that he had found a most valuable means of shortening the time required for a successful radiograph. Later experience showed that tungstate of calcium was better than the barium salt for this purpose, even after tungstate had been abandoned for the fluoroscope, and that it needed to be prepared with exceedingly fine grain to minimize the marbling of the negative. The preparation of these screens reached a high state of perfection here during 1897, and makers advertised them as a routine item of equipment. Since 1900 they have been still further improved and popularized in Europe.

They do not deteriorate with age, and only require to be kept flat and free from handling to last indefinitely. The 14 × 17 screen purchased by me in August, 1896, has always been preserved in a plate-holder, and is still as good as new. Nothing but the film of the plate, or its wrapper of fine tissue-paper, has ever been allowed in contact with the chemical side of the screen. This care preserves the original delicacy of the fine coating.

That such a reinforcement of fluorescing activity will affect the sensitive plate in less time than rays without the screen is apparent on the first test; and the rapidity is doubly enhanced by using two screens, one under the plate as well as over it. On the subject of these screens an English author thus writes:

"It has been proved by prominent workers that the use of a fluorescent screen in conjunction with a photographic plate very materially reduces the exposure required for any special case with a given outfit. It is, of course, the actinic fluorescence of the screen, which, acting directly on the plate, helps to build up the photographic image. But as the ordinary photographic dry plates are not uniformly sensitive to every kind of ray we must either have a screen which fluoresces with a photo-chemically active color, or, if we wish to use a barium screen which fluoresces a yellow-green, we must first orthochromatize the sensitive plate. As the latter process is somewhat troublesome and plates thus prepared do not keep long it is best to use a screen which fluoresces with a purple light, and for this purpose tungstate of calcium in a certain modification offers great advantages.

"The best intensifying tungstate screens are coated on a flexible support, and so evenly that very little, if any, grain or marbling will be noticed on the negative. The matt side of the screen is the coated one, and must be placed in direct contact with the film of the plate. For this purpose, therefore, a special plate-holder is required, as the envelope wrapper now furnished with X-ray plates is not convenient for the reception of the screen.

"If we coat *both sides* of the photographic plate with emulsion, and produce images in both coatings which are identical in density and in perfect register, we can obtain negatives which, for equal exposure, yield greater density; or, for equal density require only one-third the exposure of the one-sided plates and films. This system of double-sided coating is of special value in conjunction with intensifying screens, since it enables us to use two screens, thus greatly enhancing their action. The plate in this case is sandwiched between the two screens, and *the respective exposure is about one-ninth that required with an ordinary plate without any screen.* Such an arrangement will be found especially useful for the radiography of thick parts of the body, the thorax, pelvic, and abdominal regions."

As all the early observers reported that the gain in quickness of exposure was at a loss of clear detail, experiments were made to ascertain the cause. A systematic study of effects, with strips of five different screens on sections of the same plate, showed in the negative that the action of screens of different material and quality was quite different. Those which fluoresced with a violet tint gave the best result, while the platinum salts impaired the impression. The sharpest *definition* was obtained when there was no screen used. With the screen there was produced a sort of halo around the edges of the image, but this was not due to the granular nature of the material, but to a true halo caused by the diffusion of the light. This effect, being due to the fluorescent radiations, therefore increases with the time of exposure, but is obviated by using a metal backing as we show elsewhere.

With the gradual improvement in generating apparatus, tubes, and X-ray technics, the shortening of the normal exposure-time through greater efficiency of radiance lessened the opinion of the profession that an intensifying adjunct was a necessity. A screen, also, adds to the thickness of the cover of the plate-holder, lifts the part still farther from absolute contact with the film, and, at short-distance exposures, contributes to magnify the image. Recently addressing the makers of the leading fluoroscopes in this country with an inquiry as to the present sale of photographic screens, we had the following reply:

"Photographing screens are now seldom used in America, so far as we are able to judge. Some operators use them regularly, but they are ordered so infrequently that we no longer keep them in stock. Our opinion is that X-ray apparatus, and particularly photographic plates, used for this purpose, have been so improved that the use of a screen in connection with the plates is now generally inadvisable."

But let us consider the matter a little further. The finest intensifying screen of tungstate of calcium does not blur the picture very much. If it was helpful with inferior apparatus may it not be still helpful with improved apparatus? A case in point is recently cited relating to the detection of a gall-stone. Five exposures were negative in result, but on a sixth attempt the persistent operator placed an intensifying screen over the plate, made a brief exposure of fifty seconds at thirty inches, and secured "two gall-stones in the gall-bladder, one giving a very dark shadow on account of the phosphates, and the other, having a nucleus of cholesterine with phosphates around, not so plain." An operation was done, and the two stones found corresponded very exactly to the shadows in the skiagraph.

In this case exact *definition* was not the main need of diagnosis, but rather a *contrast of densities.* And this *points to the proper function of the photographic screen, and a revival of a greater usefulness than before.* To summarize:

1. When the diagnosis demands the clearest definition and sharp details of anatomy with distinctions that the screen would blur, do not use it.

2. When thin and easily skiagraphed parts are exposed no screen is needed.

3. When thick parts are exposed and the diagnosis does not involve the most absolute definition of structure but is rather a matter of contrasts and relation, the screen will greatly lessen the time required, and thus not only taxes the patient less, but also reduces the possibility of accident.

4. When a foreign body is sought the screen will catch the shadow on the plate with a reduced exposure-time, and with all its aforesaid advantages.

5. When slight contrasts of density are involved, especially in fields of soft tissues, the screen will fix the low-density shadow most quickly, and reduce the liability of losing it by a slower penetration of the denser parts. Calculi illustrate this. Under-exposures are apt to be avoided by the aid of the rapid-action screen.

The fact that experts secure calculi and other difficult shadows on plates without the aid of any screen does not indicate that any operator may not be greatly aided at times by employing it. Objectors can certainly find fault with it, but the general operator who tries to get all the help out of it that he can without any other idea than to do good work will find a photographic screen of considerable value each year that he uses it.

The above relates to *ordinary* radiography. When we come to consider the high clinical value of the *momentary* radiographs of the great German experts in thoracic diagnosis and observe that without the "intensifying screen" they cannot be generally secured, we see that they take us into a field of work which *the photographic screen has made its own*, and which does not admit of argument. Ask Levy-Dorn, Von Ziemssen, Rieder, and their many followers whether such an accessory is needed to-day or not, and they will point to a brilliant array of cases—cases in which they feel the greatest pride, and describe with satisfaction—and show that in this special field the screen is *indispensable.*

One of the foremost radiographers in England recently summarized the European status of photographic screens, in 1901, as follows:

"With respect to plates our friends across the Channel are not better off than we. They, too, are limited to plates which, however excellent for ordinary work, are deplorably deficient for X-ray records. To compensate for the insufficiency of absorption of the X-rays in the film, intensifying screens are largely made use of on the Continent, as in England, particularly since the grain has been reduced to a minimum and in the vast majority of cases does not interfere with the usefulness of the picture.

"Frequently two screens are used, one on either side of the plate (or better, film), no matter whether the latter has only one or both sides coated with emulsion. Especially when using films a second screen is a decided advantage. The specimens here shown (of instantaneous radiographs) were made on Schleussner films coated on one side only, but sandwiched in between two intensifying screens of calcium tungstate. They were made at twenty inches with a twenty-inch coil, an electrolytic break, run by the 100-volt continuous electric-lighting circuit. Exposure was made with an instantaneous electric-light switch in the primary circuit of the coil. The extreme rapidity of the exposure is clearly shown by the sharpness of the outlines of the respiratory organs, and as a further gain of the short exposure we notice a well-marked contrast in the shadow of the different tissues."

We have observed that some operators speak with impatience of the mere idea of using these screens, but dogmatism in the matter, or a "dog-in-the-manger" spirit, is out of place, for each operator seriously searching for the truth about the advantages offered by any X-ray device can *test* the matter and take no untried verdict. Some "do not *like* screens"; others say they "*try* to do without them"; but those who have made the best and most frequent use of fine screens state that they shorten the exposure about one-seventh. Some have made one, two, or a "few" trials of screens, and, regarding them as unsatisfactory, have abandoned them. But it may be recalled that in X-ray work there are a number of different view-points. When diagnosis is the end aimed at a picture may suit a surgeon when the enthusiast aiming at spectacular effects might reject it with disdain. An all-round radiographer certainly can find some valuable uses for a fine pair of screens, and when he does not need them they can be set aside. In preparing this course of instruction we sought an impartial opinion in the following manner: We requested an expert to make a set of tests, placing a part on one large plate, and dividing the plate into sections. One section to be a plain exposure; a second section to employ a screen, but to have no metallic backing to the plate; the last section to use both screen and metal backing. No test was made with two screens as the operator had but one. We have before us the prints from the resulting negatives and the report of the physician. He asserts that the tests made according to my directions prove the advantage of the screen, especially when the plate *is backed by metal.* As reproductions lose so much of the original, it will be impossible to place the evidence before the reader in a satisfactory manner. The half-tone print is not a fair substitute for the negative, and readers cannot judge of one from the other.

Metallic Protecting Screens.—What is meant by a device thus named is a sheet of opaque metal over the tissues exposed for diagnostic or medical purposes, or a transparent sheet of thin aluminum connected with a wire to earth.

In surgical exposures for diagnosis the protecting screen originated from a desire to keep from the exposed tissues the particular rays that caused X-ray burns during the making of radiographs. These screens are generally a very thin sheet of aluminum, and are not cut with a window. They are not put on the skin or over any pasteboard mask, but are supported by the tube-holder much nearer to the tube itself than to the patient. One is usually connected to a gas or water pipe to "ground" it, and to carry away electrostatic discharges. Many metals and other substances have been tentatively employed for this purpose during the past five years of radiographic work, and opinions as to their need and value differ.

Where one operator uses such a device a hundred do not. It is wise to expose the patient by modern methods that call for no "protection" rather than to create a risk by poor practice. So far as known to the author none of the world's leading masters of radiography use a grounded screen in taking their pictures. With 1902 apparatus it seems superfluous.

In medical work the purpose is to shield the healthy tissues around the lesion from possible ill-effects, while the action is limited to the diseased part. To let the rays pass to the diseased part a hole is cut in the metal sheet corresponding to the area of the lesion, or surface treated. In medical work on the face a common pasteboard mask is often used as the backing and layers of tin-foil are laid on its front, save over the area to be treated. Or, a piece of sheet-lead is cut and bent to fit over the face. For any part of the body the principle is the same, and the arrangement of the device is governed by convenience.

The metals most used are sheet-lead and tin-foil, as they are easily cut, are cheap, and can be obtained in various thicknesses. Do not lay the metal directly on the skin of the part, but either support it at an appreciable distance or put a layer of cardboard, blotting-paper, or cloth under it on the skin.

No such devices as "lead masks" are for sale by dealers so far as the author is aware, and the ingenuity of individual operators prepares what is needed for a given patient. They are improvised affairs, some holding that *they are not required at all. Some use them because it has been the mode, and for fear that failure to do so will lay them open to charges of neglect of proper technics.* Time and experience will settle the matter.

In a discussion on the subject of protecting screens, Payne remarked:

"I made several experiments with screens, which I mentioned in a discussion a year ago. It seems to me that if you have a metal screen, and it is touching the body, you will have a different effect from that which will result if the screen is a little way off. If the metal screen is touching the skin, the latter will not be protected from the discharge. If, on the other hand, it is a short distance away, and grounded, every impulse given to the tube by the coil will induce a charge on the screen, which again may have an effect on the skin by induction. The metal screen does not seem satisfactory. If the screen could be made of some highly insulated material, we should perhaps get rid of these defects. If we could devise a screen that would keep off any electrical effects or discharges other than the X-rays, we would be able to determine whether the X-rays have any therapeutic effects, or not."

We have in plain, dry, tightly woven *paper* such a highly insulating material as Payne desires. A fine quality of paper, in a perfectly dry state, is a better insulator than glass, and is equal, if not superior, to the best hard rubber. For years I have employed it as a protector of the tissues in certain applications with high potential electricity, and it is very transparent to X-rays. It does not need grounding, as it is not a conductor. It does not set up induction. It is cheap, always at hand, can be cut and shaped to suit, and does not spark at the edges when in the electro-static field. By using a greater or less number of sheets, or employing sheets of cardboard, the desired thickness can be regulated to suit the needs of any case.

Flexible Lead Mask.—Take a clean piece of soft linen of sufficient size to more than cover the part; take a piece of sheet-lead about as thick as an ordinary business card and a little smaller than the linen; make a paper pattern of the diseased area and then cut out the lead a trifle smaller, so that when laid on the part the hole will fit just within the margin of disease; sew the linen and sheet of lead together, and fold the edges of the linen over all borders of the lead so that no metal contact will be made with the tissues, especially around the hole applied to the lesion; then adapt the completed mask to the part and attach tie-strings to hold it in place during treatment. This has some advantages over a mask made on a cardboard foundation.

Do not forget that as healing takes place and the affected area shrinks, the hole in the lead shield must be reduced to fit as accurately as at first. Do not make the mistake of treating a lesion that has become one-half its first size with a shield cut to fit the original area

PLATE 17.—Section of Hip-joint showing definition obtainable with intensifying screen. Radiographed by Dr. Jicinsky. Exposure ten minutes with tube at twenty inches. Dislocation of femur discovered by the X-rays. Had been diagnosed as fracture of neck without the rays. Allowing for loss of detail in reproducing processes it will be seen that a fine tungstate of calcium screen laid on the film to assist the exposure does not necessarily mottle and blur the picture. The original print of this radiograph in the author's hands is beautifully clear and would please any critic.

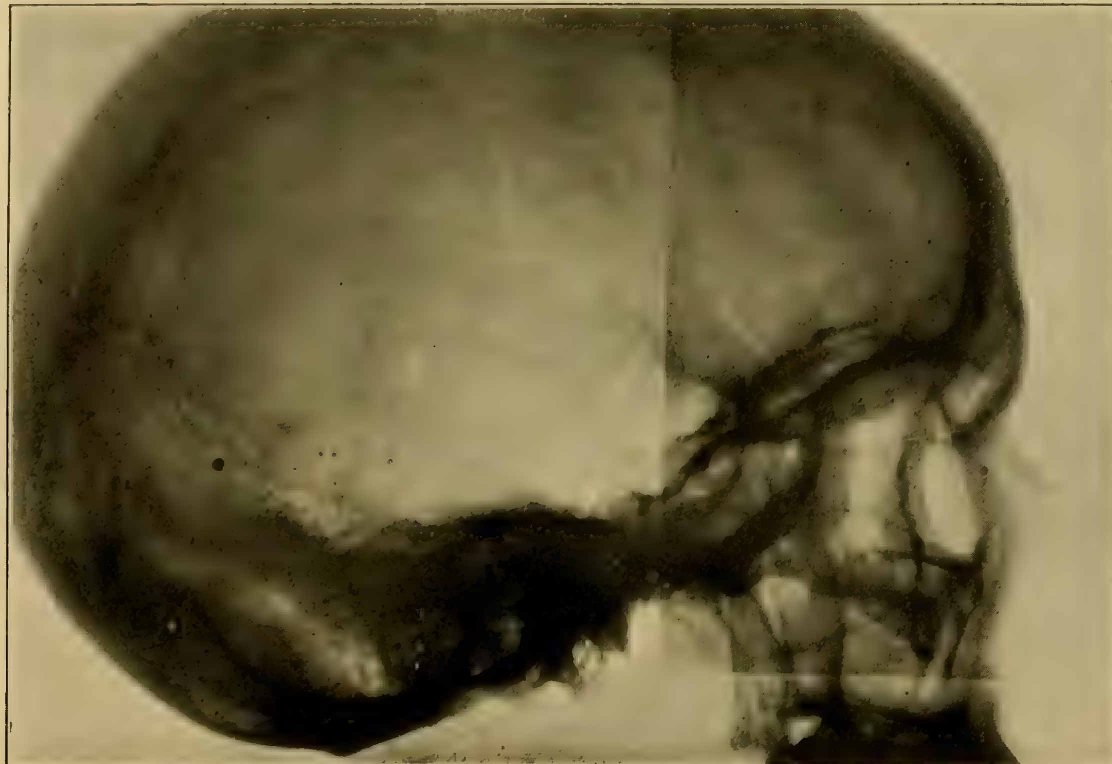


PLATE 18.—Another example showing definition obtainable with photographic screen on film. Radiographed by Dr. Jicinsky as a test for this book. Several others are omitted for lack of space, but this head and the section of hip suffice to show that the screen does not spoil the detail as some claim. Compare these radiographs with our text on this subject.

PLATE 19.—Rheumatic Gout of the Hand. "Closely inspected this picture presents some interesting features to the expert and contains evidence questioning the diagnosis of rheumatic gout. If it illustrates bone changes that have not been supposed to be caused by this disease, but which may occur in its late stages, the X-ray will alter the common opinion of the ultimate nature of the alterations set up in the tissues." (Rebman. Ltd.)

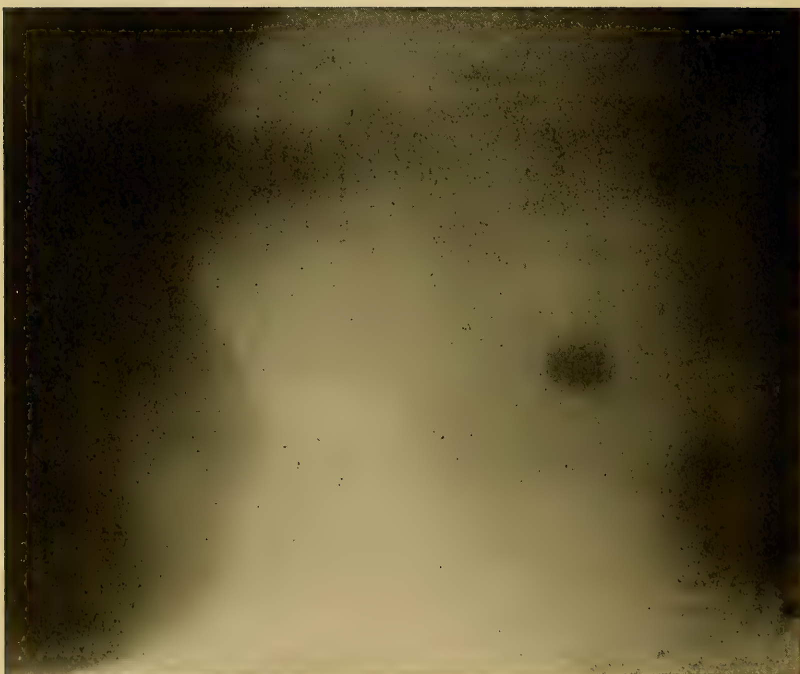


Plate 20. – Calculus in the Left Kidney. In this case all the ordinary signs of renal calculus were absent, but a stone was suspected and was held to be in the cortex of the kidney. The radiograph changed the diagnosis into a certainty and the operation secured from the centre of the kidney an oxalate of lime calculus three-quarters by one-half an inch in size. Tube, 18 inches; time, 8 minutes; 10-inch coil. The reduced picture here shown fails to do justice to the negative.

This picture is a print from an electrotype from a fine half-tone reproduction from a print from a fine negative. In the four steps from the original to this page the entire value of the picture has been lost, and it is here inserted only to point out to those who form a poor opinion of an X-ray image from such illustrations as this that their judgment is based on wrong premises. Blurred reproductions are not the basis of the diagnostic value of the X-rays.

and never altered. Keep a supply of heavy foil or thin sheet-lead on hand, and fit new shields as needed.

Lead Shield for Malignant Disease.—In the X-ray treatment of the superficial forms of cancer which are being treated in increasing variety and success by X-rays, the rule for fitting the hole of the shield over the lesion is exactly opposite to that for lupus and ulcers. The fact that deeper portions of the growth extend under the margins of the apparently healthy area of the skin makes it of the first importance to include a sufficient margin of tissue in the exposure to the rays. Recurrence or subsequent extension in early cases reported may be traced in part to the omission of this detail of technic. All directions in this course relating to making the hole smaller than the actual area of disease apply to other conditions than cancer, or to lesions which are largest at the surface. Any lesion which may be larger below the surface than the area of the skin-line should have treatment directed to its maximum extension even if covered by normal skin in part. Remember this general principle of application.

Various writers have remarked that the metal of a mask should not touch the skin as "it would cause irritation," but none explain *why*. The truth is that if the metal really made *contact* with the tissues there would be no irritation. There may be a great difference between "touching" a part and *electrical contact* with the same part, just as there is a vast difference between a cook's idea of a clean knife and surgical cleanliness of a knife for an operation. Electrical contact is not a mere approximation, but *a continuity of conduction between two conductors.* When a current of high voltage is discharged in a room it charges metallic objects within its electro-static field. These in turn discharge to the great magnet, the earth, or to any other object brought near enough to attract the charge. If there is any insulating space between the charged body and the attracting object the discharge will fly across it in the form of a small spark or series of minute sparks, and these are like the sharp needle-sparks familiar to all who use static electricity.

With the small currents used in X-ray work, and with the metal of the mask apparently touching the skin of the patient, it does not make electrical *contact* if there are dry hairs or scaly dry skin between the current and conducting tissues. If they were wet with water hair and crusts would conduct the current without the minute spark-gap, but when dry they act as a resistance and force the current to jump across them to reach the tissues. Then the energy expended sets up heat and irritation; but if the metal is removed just beyond the minute distance which the discharge can jump across, it is insulated from the tissues and hence does not attack them with the small sparks. Therefore, to eliminate these we may either insert too much resistance by lining the lead with cardboard, etc., or we may cut out all resistance by actual electrical contact, or we may carry off the discharge silently by a metal conductor to earth. In the latter case the patient will not feel it at all, for all currents take the path of least resistance.

Read this explanation carefully and appreciate the simple statement of facts that puzzle many whose experience has been without instruction. To "ground" the mask hook a light chain or wire to a convenient gas fixture and hook the other end into a hole in one corner of the mask. When this is done there is no further question of "keeping the metal from touching the patient's tissues."

Selected Tin-Foil for X-Ray Masks.—Practitioners and hospitals seldom know where to get the most suitable foil for X-ray work, and it will render a service to many to give the information here. Speaking for this city we find sheet-lead in plumbers' supply stores, but the thinnest kept in stock weighs about three pounds to the square foot. This is too heavy for face-masks and for close fitting to a part. Price, eight cents a pound at retail. After much search and many inquiries we have traced head-quarters in the manufacture of all kinds of tin-foil. For facial shields and all cases requiring a medium, flexible, and easily moulded foil the kind to get is known as "Tea lead foil No. 1." It is neat, clean, silvery, and can be ordered in any size, sheet or roll. One pound yields a sheet a foot wide and four feet long. The retail price is ten cents a pound. For additional thickness use more than one layer when needed. It is made by "The Conley Foil Company," Nos. 521 to 541 West Twenty-fifth Street, New York, who will furnish it to physicians and hospitals in any quantity. Their name is mentioned here simply as a kindness to my colleagues, to whom the knowledge of where to procure the foil is worth far more than the slight cost of it. Heavier foils are also made by this firm, but are less readily shaped about irregular parts. It is well, however, to have some of the heavy foil on hand for flat uses.

CHAPTER X

STUDIES IN THE OPERATION OF X-RAY TUBES

A Study of Electrical Dosage. The Essential Bombardment. Tests. Static Methods. Fluctuations of Tubes. The Travelling Focus. Dosage of Current for Tube a Factor in Avoiding Dermatitis. Magnetic Augmentation of X-Radiance.

What may be called the dose regulation of current for Crookes tubes possessing a suitable vacuum involves practically three features of control—pressure, volume, and interruption. On the *pressure* and *quality of interruption* depend the intensity of the bombardment of the cathode stream upon the anode, and on the *volume* of the electrical discharge depends the opulence of the rays—the factor which gives richness of detail to the picture. Therefore, the regulation of dosage to adapt the electric-current to the production of the required degree of X-radiance is as essential as the proper dosage of drugs for desired therapeutic actions.

In the regulation of coil-currents the form of controller which governs the primary voltage and amperage is an obvious mechanical device, which requires no skill to operate. Practically, nearly all requirements of judgment and experience relate to the *interrupter*. As every coil-current is an interrupted current the only question is the regulation of the particular device upon your own apparatus. About 100 varieties of interrupters have been distributed by different makers among X-ray workers prior to this date. For the most part they are variations of spring vibrators, revolving wheels, electrolytic, and mercury, types; but the exact regulation of each is peculiar to itself. The many pages required to instruct the reader without knowing what type he possessed would be wasted, and it is a simple matter to have the seller explain the switches, set-screws, and combinations of the coil you purchase, at the time it is delivered. Certain principles, however, can be set forth here.

High intensity in the bombardment is required to transform the current at the cathode and atomize it. Simple continuous *pressure* will not best accomplish this object, however high the pressure may be. It requires a fusillade of *blows*. This is beautifully illustrated with the Static machine.

Connect the suitable tube directly to the prime conductors with the poles drawn widely apart, and without any break in the electrical conductors. Start the machine slowly into action and watch the cathode. The tube will light up with a dull glow, no activity will be visible on the glass nearest the rim of the cathode, and the fluoroscope will show that very feeble X-rays are developed. Next increase the speed of the plates a little. There may be a slight increase in luminosity, but inspection of the cathode shows that there is no *furious bombardment* from the electric-current such as is needed for the development of efficient X-rays.

As the current from the Static machine is next increased, the pressure will reach a point when it breaks down the resistance between the rim of the cathode and the neighboring glass wall of the tube. Now, observe the effect. Like the halo round a picture of the sun we see fine streams of sparks infinitely small radiating upon the glass. The bombardment has changed from simple pressure into the rapid-fire volleys of intense strain, *which must be set up by some means somewhere in the circuit* in order to excite X-rays. The dull glow of the tube instantly changes to the apple-green radiance which delights the operator. The fluoroscope shows rays of richness and penetration. The necessary *interruption* has been supplied by the *discharge between the rim of the cathode and the glass*, without the aid of any external break.

Tubes which are well adapted to work with Static machines will supply this form of interruption steadily, without noise, without strain upon the tube, with scarcely more than blood heat, and with a brilliancy of radiance equal to any that can be obtained with equal currents. Owing to variations in the pressure, a tube, however, is liable to intermit this cathode-rim discharge, and with its disappearance the X-rays diminish. But in every case, when it takes place steadily, it illustrates with great beauty and clearness the principle of X-ray excitations, and affords a means of study from which the operator can learn much. To become independent of chance in establishing the essential intensity of bombardment, an *external interrupter* is employed which can always break the current and maintain steadiness of action. When the external interrupter acts as the intensifier watch the cathode, and note that the radiations to the glass are altered. The substitute break of the current dominates them.

With all varieties of therapeutic Static machines, there are three methods of operating a Crookes tube.

1. Direct Current.—Connect the tube to the prime conductors by the usual wires. Draw the poles a foot apart. Start the machine into rapid action. If the tube immediately lights up, simply regulate the speed of the plates to produce the desired degree of radiance. If the tube does not promptly fluoresce with a pressure current push one sliding pole toward the other until a spark jumps and disturbs the circuit. A tube will often light up after one or two sparks. If it does so draw the poles again apart, and the tube is ready for work. This method of using the current requires a tube which furnishes its own bombardment from the rim of the cathode. It requires neither Leyden jars nor interrupting devices, but there must be a *bombardment* somewhere.

In my original work, written when my largest Static machine was but half the size of what may be considered the present standard, it was recommended to connect the largest Leyden jars beneath the pole-pieces without making the circuit between their outer coatings. It was considered that they might produce a possible reinforcement of the current, although carefully tested effects with and without them failed to distinguish any difference. With the development of currents of higher efficiency from much larger machines than the ordinary eight and ten plate thirty-inch machines in general use, I have long since ceased to pay any attention to Leyden jars in connection with X-ray work.

2. Interrupted Direct Current.—This is the most practical and certain method to employ. Place a pair of the author's interrupters upon the handles of the sliding poles of the Static machine, so that the terminal ball of each interrupter makes contact with the outer ball of each prime conductor about one inch from the joint of the vulcanite handle. Shift the collar of the interrupter back to within half an inch of its own vulcanite handle and screw it securely upon the handle of the prime conductor. Do the same at the opposite pole. Connect the wires from the tube either through the eye of the flat piece below the collar of the interrupter, or to the brass rod behind it.

Start the machine into action with the balls of both interrupters in contact with the balls of the two prime conductors, so that there is no interruption in the circuit. Draw the poles widely apart. As the tube either dimly or brightly lights up slowly twist the handle of the negative interrupter so that the metal ball upon the curved end of the metallic rod of the device will gradually separate from the ball of the Static machine and open the spark-gap. The length of this spark-gap may be varied from infinitesimal thickness to about an inch by a simple twist of the handle. It may be done very slowly or with a quick movement, according to the action desired.

To regulate the proper length of spark-gap, vary it while watching the tube, and when the tube works at its best or supplies the desired degree of X-radiance, the dosage is adjusted so far as the negative interrupter is concerned. If, however, a greater length of spark is needed, pull the rod directly through its retaining sleeve till the ball of the interrupter is drawn as far away from the ball of the prime conductor as may be desired. The maximum distance is limited to that through which a steady spark-stream will pass, or approximately, two inches.

If the bombardment is not yet sufficiently *intensified*, repeat the same process at the positive pole, and increase the speed of the plates. The development of the maximum current of the machine, and the maximum spark-gaps which can be regulated to steady action, represent the limit of the apparatus with a given tube. The principle of operating other forms of Static-machine interrupters is the same. Makers vary the shape of the device but not the principles of dosage.

These interrupters not only steady a flickering tube, but enormously increase the efficiency of tubes of medium and low vacuum-resistance. They practically add their own spark-gap to the spark-gap rating of the given tube, with the advantage that the *external* resistance is always adjustable. They greatly aid to drive the current through any tube whose resistance is somewhat high, but not too high, for the capacity of the given Static machine.

It is generally an improvement to interrupt the current at *both* poles with a *low* tube. It is generally advisable to interrupt only the *negative* side of the current with a high tube. All points of regulation are, however, independent of theory, for a moment's test demonstrates to the operator exactly what to do.

Besides the particular form devised by the author the same principle is applied to other designs of Static machines by what are called "spark-gap posts." It is simply a matter of mechanical form. The manner in which the spark is made to break the current is not important if the quality of action is secured.

These interrupters are adjusters of the total resistance of the circuit auxiliary to the vacuum-resistance of the tube. In addition to this, they are regulators of the intensity of the electrical bombardment of the cathode, and thus fulfil three important functions. Until they were introduced the dosage of the direct Static machine current was dominated by the internal state of the tube. By their aid the situation is reversed, and the wide range of flexibility they impart to regulation of the current enables the operator to dominate any and all tubes below an excessively high exhaustion. They steady the action of the formerly uncertain current-pressure as a firm grip steadies a wavering arm.

They, of course, produce satisfaction in proportion to the *fatness* of the current with which they are employed, and *currents from more energetic machines than the ordinary eight- and ten-plate sizes demonstrate their value most effectively.* It may be said here in passing that too much of the general measure of the efficiency of static electricity is ignorantly based on observations of small currents, which deal with both tubes and tissues as a hatchet (instead of an axe), would deal with a large tree. No woodman witnessing the chopping qualities of a large and keen axe would hold up a hatchet as the standard of working efficiency, yet the common idea of static electricity is founded on currents of but hatchet size.

Author's Short-Circuit Stick.—When a coil is used for X-ray work a switch cuts in the full current at once and in the same manner cuts it off. But when the Static machine is used the current increases gradually and does not attain its maximum till rapid speed of the plates develops, and when the revolving plates are slacking up the current dies out by degrees instead of by a sudden cut-off. For this reason exposures for radiographs cannot be limited to an exact number of seconds of maximum radiance when starting and stopping the Static machine in the usual way. A means of creating an immediate short-circuit is necessary.

In my early teaching of X-ray technics I was accustomed to use the brass rod called the "shepherd's crook," but, being metal, its use may be annoying to those who dislike the contractions at the wrist which occur at the moments of make and break, especially when a powerful interruption energizes the current. A non-conducting *handle* corrects this fault. Such a device is indispensable and is made as follows:

Take any thin strip or stick of light wood four and one-half feet long. On one flat side of this narrow stick tack any convenient strip of metal, or small chain, or wire, that will serve the purpose of a conductor from the distal end of the wood along twenty-eight inches toward the handle. This leaves a long end of the wood free from metal, and this is used as the handle end.

In practice, when all is ready for the exposure except exciting the tube, take this short-circuit stick by the bare wood end and lay it across the poles of the Static machine so that the wire or strip of metal on the distal half will bridge over the space from contact on one pole to contact on the other. Start the machine into action (with the adjustment known from previous test to be required to properly work the given tube), and when full speed is attained lift away the stick. While the stick is on the poles no current reaches the tube at all. When the stick is lifted the full X-radiance begins sharply, and the time can be noted to a second with the watch.

When the time is nearly up take the stick and stand, watch in hand, beside the machine. At the precise second desired lay the stick across the poles, and the metallic circuit instantly shunts off the current from the tube and the X-rays cease action. There is no sensation to the operator or patient, and the simplicity of the method is perfection. The same device enables us to cut off the current at any moment to adjust a contact, tube, wire, or any part of the apparatus, or to substitute another tube, without delaying to stop and re-start the Static machine. The cost of the instrument need not be three cents, but its practical utility is worth many dollars in time, convenience, and satisfaction. No Static-machine operator should remain a day without one. It is also useful in therapeutic practice.

3. Leyden Jar Current.—Connect the terminals of the tube to the outer coatings of a pair of smallest Leyden jars connected properly with the prime conductors of the Static machine. Short circuit the sliding poles and start the current into action. Gradually draw the poles apart three, four, five, six, eight, or more inches (according to the machine), until the maximum or desired degree of radiance is secured with the image still steady. Do not separate the poles so widely that the spark-stream becomes irregular and causes flickering of the image on the screen.

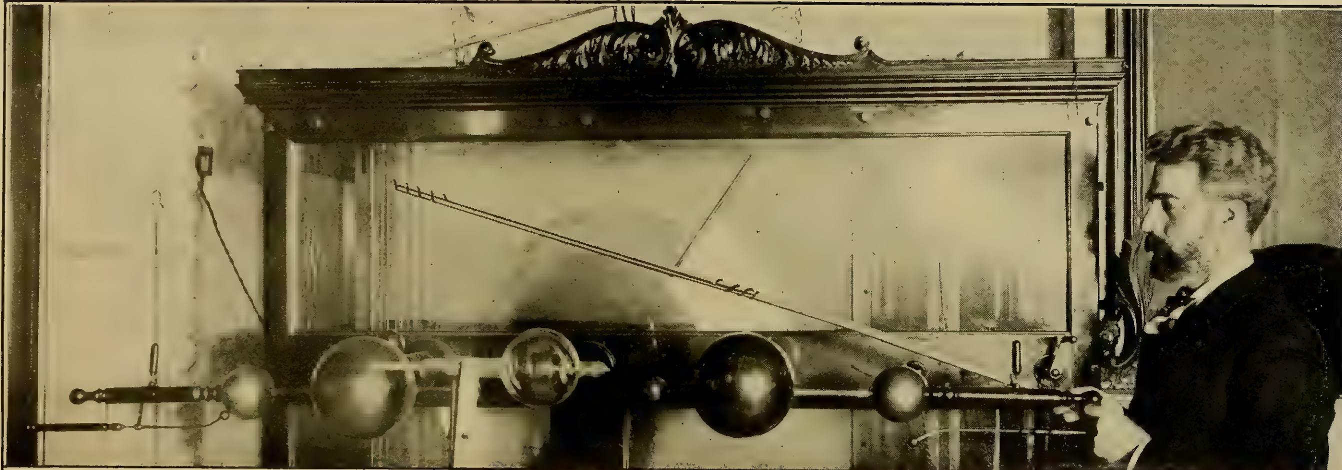
Remember that Leyden jars reverse the direct polarity of the prime conductors. If you have forgotten this and do not succeed in obtaining satisfactory X-rays on the first attempt, with a medium or low-resistance tube, turn it around and try it the other way. With the Leyden jar method, some X-rays will be produced, even when a tube is connected with the cathode to the positive jar.

High-vacuum tubes are not suited to the Leyden jar shunt-current as it cannot handle the resistance. Use only the very small Leyden jars, for the reason that the discharge must be rapid, and it takes large jars too long to fill and empty. If in doubt about the matter simply make the experiment, and the objections to jars of two or four quarts capacity will demonstrates themselves.

Dosage of Current for a Given Tube.—While the amount of current required to excite a tube is proportioned to the size and internal resistance which it presents to the current, yet the two factors, voltage and amperage, here go hand in hand together as they do in so much of the work of electricity. A small tube of a given resistance

PLATE 21.—Author's Test for Tension of Static Current. Sit on insulated platform and ground either pole. Let out strands till they fall to floor. Note degree of strain. Then let them fly from the hand. A large current will hold out six feet of light cotton cord and drive it ten feet or more when released. This far surpasses the usual spark test. A current not equal to this illustration is too small for fine X-ray or therapeutic work. The author's machine is at the right of the patient and omitted from the cut.

(This photograph was taken in the author's office during the "dog days" of 1901, when the humidity was reaching 88, 91, to 95 degrees, according to official reports. The strands extended by the current in the picture are only 44 inches long, but the tension would throw them ten feet when released. From the first week of July till the author left the city September 9th on his vacation this machine never discharged, even while idle over Sundays each week. This fact is merely stated to show the working of the Static machine in summer in the author's hands.)



Quickly lift the stick from both poles to break the circuit, or lay it on them to short-circuit the current.

PLATE 22.—Author's Short-Circuit Stick. In the lower figure the stick is laid on the poles and shunts the current from the tube. In the upper figure the operator is seen lifting it from the poles to let the current excite the tube for the required exposure-time. See text for full description.

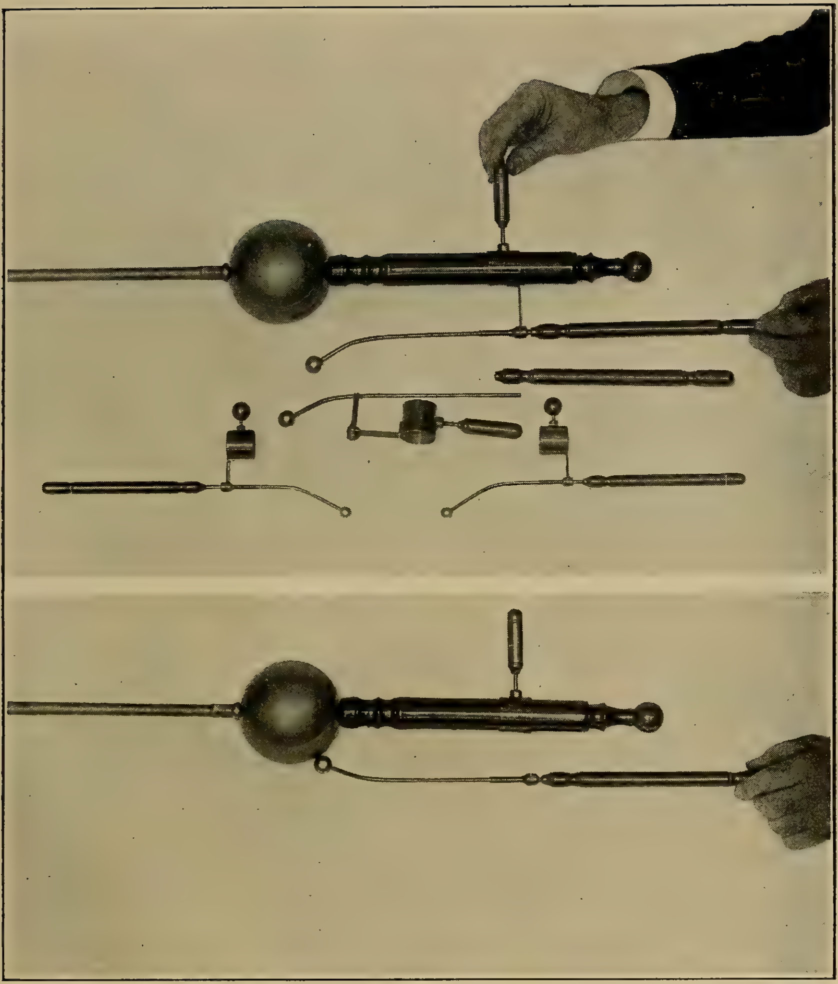


PLATE 23.—Author's Interrupters for large Static Machines. Slip the metal collar of one Interrupter over the vulcanite handle of the Static sliding pole and fix it in place with set-screw as shown in upper illustration. The spark-gap between the balls is here open. To close the gap and use a continuous current make a half turn of the handle till the balls meet as shown in the lower figure. To increase the spark-gap more than a turn pull the handle of the interrupter through its sleeve and away from the prime conductor. To clean and polish the brass parts take the interrupters apart as shown in the upper figure. The smaller pair shows right and left positions of the interrupters when on the opposite poles.

The model pictured in my original volume early in 1897 is here greatly improved upon. The newer insulating handles are nine inches long and protect the operator from sparks when regulating the powerful current. The long handle to the set-screw is a convenience. It is of prime importance to have the rod fit tightly in the sleeve through which it turns and slides, so that when the ball is placed in contact with the direct conductor of the sliding pole, or at any desired distance from it, it will remain fixed. It is equally important to keep the brass parts of the interrupters polished. Oxidation upon the rod and terminal ball reduces conductivity and impairs the fine quality of the break. The same is true of the brass parts of the poles of the Static machine. Observe particularly the bend in the rod of the above model. The advantage of this curve is easily seen in practice, and the author has not used a straight rod in any of his interrupters since 1898.

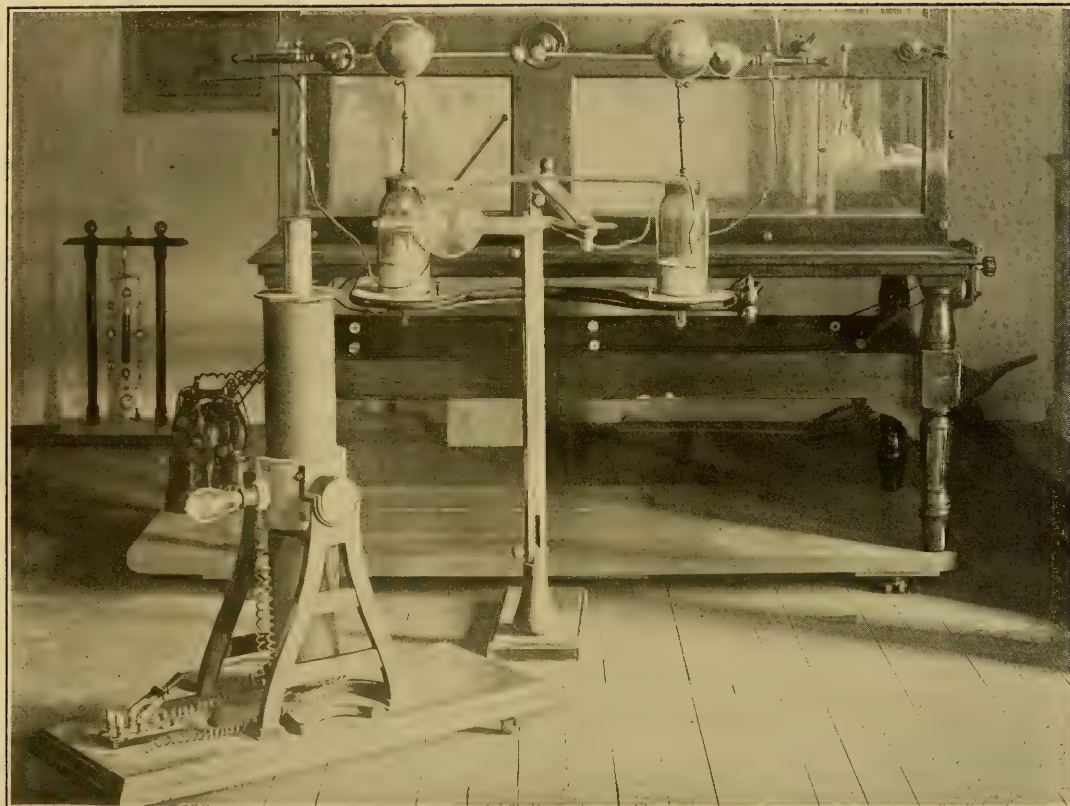


Plate 24.—Combined Coil and Static Machine to Increase X-Radiance. See text for description.

can be highly excited with a current that would be far too little dosage for a large tube of the same relative resistance, because the moderate voltage will break down the resistance of the small tube, and the volume will be ample for the restricted area to be bombarded. But spread out over the surface of larger electrodes and of the glass of a large tube the volume of a small current makes too thin a bombardment to be effective, *i.e.*, it is too small a *dose* for the tube.

This explains why tubes must be adapted to the generator employed, whether coil or Static machine. A pony will not do all the work of a big horse, and a four-inch spark-current will not do all the work of a ten-, twelve-, or eighteen-inch spark-current.

But to set up an intense bombardment a current must have thickness, volume, and quantity as well as driving voltage-force. A long, thin spark is not evidence of a good apparatus. The spark must show fat proportions. It must be *thick*. In a coil this essential quality usually means more copper and more cost. In a Static machine it means more parallel revolving plates, and more cost also. Says a coil-maker, "By experiments I have found I can get as good, if not better, results with the fluoroscope, and take as good a picture with the same length of exposure, using the same tube in both experiments, with an eight-inch spark-coil with a No. 32 wire secondary, as I can with a twelve-inch spark-coil wound with a fine No. 36 secondary." The larger volume of the *coarser wire* lends more efficiency to a given voltage than the thin current of the thirty-six wire.

The same principle is demonstrated with the Static machine. Using the same tube and taking the same part of the body at the same distance and same exposure time, the maximum radiance developed by a Static machine with 300 square inches of generating surface was manifestly inferior to the negative produced by a machine with 512 square inches of generating surface. It is conclusively settled, then, that efficiency in any form of current requires a fat, thick, as well as high-potential discharge.

But, granted that apparatus supplies ample current, we must regulate it to some degree to suit the conditions of the work in hand. The objection to an under-dose is the obvious one that it will not do the work, but there are two objections to an over-dose which are hardly appreciated by operators. They are so important that it will be well to study them a moment. In the first place, the habitual use of too heavy a current "dose" for the tube tends to heat, increases the liability of puncture, raises the resistance, and shortens the life of the tube. Secondly, it is one of the chief factors in causing the irritative effects which are unfortunately known as X-ray burns.

However, with the more general introduction of recent regulating devices, the whole matter of dosage, formerly calling for much experience, will be simplified.

How to Test Tubes with a Static Machine.—Attach the connecting wires from the tube directly to the prime conductor of the Static machine, without Leyden jars or interrupters in the circuit. Darken the room, short-circuit the sliding poles, and start the revolving plates into action. When they attain an average speed gradually draw the poles apart, and note how long a spark-stream can be developed. The ball terminals of the sliding poles should always be brightly polished, as oxidation lessens the value of the test. One of three things will appear as the poles are very slowly drawn apart:

1. The spark-stream may attain a length of one, one and a half, or two inches, or a little more, and as the poles are drawn beyond this distance the spark will cease and the tube will suddenly glow with the proper green luminosity, and the fluoroscope will demonstrate X-rays.

2. The spark-stream may be less than one inch, or be any length down to the mere thickness of a sheet of paper between the poles, and in proportion as the spark is short the green glow will become dull, bluish, or slightly pinkish, or absent entirely; and when only very short sparks occur, the electrical discharge will form a visible bluish pencil directly between the two electrodes within the tube, instead of the invisible cathode cone. This denotes a lower vacuum, and if the discharge is decidedly pink the tube is too low for X-rays and requires exhaustion. If the discharge, in rare cases, passes between the anode and cathode unaltered from a similar discharge in the open air, it proves that the tube has entirely lost its vacuum. It may have lost it by puncture, or may never have been exhausted.

3. The poles may be drawn apart beyond the longest distance that any spark will pass between them, and the current may back up and leak from the connecting wires without going through the tube, which will remain dark, or occasionally a flicker may pass through it. This proves that the *resistance* at the moment is high, but it does not at once prove that the tube actually has a high *vacuum*.

If the immediate result is seen to be Number 1 the tube has a satisfactory vacuum, and is ready for work. It will require modifications of dosage and a proper regulation of the bombardment to vary its efficiency from minimum to maximum, and will not be actually operated under the conditions of the test. With a really large static current, generated by sixteen, twenty, or twenty-four revolving plates, thirty inches in diameter, and with the author's interrupters, almost any tube that tests up a resistance not lower than half an inch spark-gap can be worked with excellent efficiency.

If the result is Number 2 the resistance is too low, and it then becomes a question to decide whether it is a temporary state of the tube or a permanent condition of too low vacuum. If the tube is manipulated as directed under separate instructions on the management of tubes, the question can be determined in a moment, and the tube rejected or returned to the makers to be exhausted if the test shows this to be necessary.

If, however, the result is Number 3 the resistance for the moment is too high, but it is not yet proved that the tube actually possesses a high vacuum. If the indicated manipulation will not get the current through it, or if it can be lighted up momentarily, but will not hold, and if in the dark brush-discharges are seen backing up not only at the terminals, but all along the connecting wires, the vacuum is then determined to be too great for the electrical pressure. A resistance that would back up the current of a small eight- or ten-plate machine, would yield readily to the pressure from a machine double the size. In proportion as the operator possesses energy in the electrical discharge he loses trouble with the resistance of what, with small apparatus, appear to be high-vacuum tubes.

If the resistance can be reduced to a working point the tube will be satisfactory. This can be determined in about two minutes by manipulation. If it *remains* too high for the operator despite the above tests it may be rejected.

Note that the length of a static parallel spark-gap is very different from the coil. The higher E.M.F. of the static-current breaks down the gap quicker. A half-inch gap by static measure might be three or more inches by a coil. A three-inch static resistance would be a very much longer spark-gap with a coil.

The Travelling Focus.—Among the causes of blurred shadows due to movement or deviation from absolute steadiness somewhere in the field of operation, must be mentioned the shifting of the focus of the cathode bombardment upon the anode. This can be seen and usually corrected when it occurs.

It is caused by disturbance and irregularity in the electrical discharges. In a darkened room and with the anode below red heat the focus spot can be plainly seen. Adjust the dosage of current through the tube till the focus is visibly localized, and then observe it for a moment. If the voltage is excessive for the tube and the interruptions are not even and steady in character, the focus spot will often be seen to travel instead of remaining stationary. If it fluctuates around over the anode it will have the effect of a moving camera on a photograph, and sharp outlines will be impossible to secure. To correct the fault in the bombardment first correct the fault in the quality of the interruption of the current and adjust the electrical discharges to a smooth and even action. Beginners will entirely overlook this source of trouble till it is pointed out to them. Every operator should be alert to detect this shifting of the point of the cathode cone while tuning his tube for exposures, as no fine picture can be made with a travelling focus. See also remarks on augmentation of X-rays by an electro-magnet. This steadies the focus, as reported by Professor Gates.

Dosage of Current for Tube a Factor in Avoiding Dermatitis in X-Ray Therapy.—From careful consideration of effects and the general lack of regard to fine details of X-ray work, especially on the electrical side of the technic, it appears to the author that random dosage has much to do with effects which many writers perplexedly attribute to "the (mysterious?) condition of the tube." In my experience I have observed that there is a point at which the excitation of the tube is the nearest to what may be called for lack of a better phrase, a comfortable tolerance of the current. That is, the energy of the electrical bombardment and the resistance of the tube come the nearest to balancing each other. At this point the conditions around the tube are nearest normal, and there is no excess of discharge to spend itself harmfully upon the patient. With the Static machine this point of dosage can be regulated exactly, and also with all coils with means of full current control. The method is this: simply take a medium and efficient tube, excite it with a temporary excess of current, and then reduce the current till the anode loses its excess of redness. At the point when current and tube work easily and efficiently together with the anode just sufficiently but not too much heated, hold the current at the given dosage. Above all, do not put the tube too near the tissues.

Magnetic Augmentation of X-Radiance.—The accompanying picture of combined coil and Static machine was kindly furnished the author by Professor Elmer Gates, with the following account of his experiments:

"The interest which attaches to this experiment lies in the fact that the radiation can be rendered more steady, and the centre of incandescence on the anode can be confined strictly to that part of the metal where you desire it, and the luminosity is greatly increased. That the luminosity is very greatly augmented can be very clearly proved.

"I recently placed a powerful electro-magnet near one end of an X-ray tube, and found that when the magnet was excited it produced a very conspicuous increase of intensity of the X-rays. The bones of the hand could be distinctly seen through a fluoroscope at a much greater distance when the magnet was charged than when it was not. By interposing books between a key and the fluoroscope until the key was invisible, and then charging the magnet, I could easily distinguish the key with the augmented radiance. Old X-ray tubes which had become too high would operate with the assistance of the electro-magnet.

"I used a ten-plate thirty-two inch Static machine, and when running at full capacity it keeps the platinum in the tube slightly red-hot at the focus point. When the magnet is charged this platinum electrode immediately becomes glowingly incandescent. In working with this Static machine and with the same tubes none of us had ever before been burned, it being perfectly safe to expose any part for two or three hours to the action of the X-rays. But when this electro-magnetic experiment was made we all felt a decided irritation of the skin of our hands and faces after six or eight minutes' exposure. The core of the magnet used is thirty-six inches long, two inches in diameter, and takes a current of 110 volts and twelve amperes. Effects were noticeable with a weak magnet, but were not conspicuous until I used a powerful coil. The apple-green luminosity of the tube is increased four or five times, possibly ten times, when the current is on the coil. The core of the coil is placed somewhat nearer the anodes than is shown in the picture.

"On the same day I studied the effect of the magnet on the stratification phenomenon of a Geisler tube. I have a long Geisler tube which, with my machine, gives a stratified appearance of waves at least three-fourths of an inch long; but when the core of the magnetized coil is close to the tube these waves become about one-eighth of an inch long, or even shorter, and the rate is correspondingly increased.

"The electro-magnet has a good effect in steadying the bombardment within the tube, holding the cathode-stream so that it does not shift its focus, which is an important matter. It may be that this method will shorten X-ray exposures, and serve to prevent the flickering which often blurs the image.

"While demonstrating the phenomenon to an electrical expert from the Patent Office, I noticed that I could get the apple-green radiation at great intensity with one position of the magnet, and by a little change in its position and distance from the machine I got an entire absence of the apple-green radiation, and in its place a most intense purely violet radiation from the anode."

CHAPTER XI

STUDIES IN FLUOROSCOPIC TECHNICS

THE FLUOROSCOPE. STUDIES OF ITS UTILITY IN PRACTICE. SELECTION AND CARE OF THE INSTRUMENT. CORRECT FLUOROSCOPY. EXACT TECHNICS. OPEN FLUORESCING SCREEN. DARKENING THE X-RAY OPERATING-ROOM. DARKENING TUBE DEVICES. LIGHT SCREEN. THE STEREOSCOPIC FLUOROSCOPE. THE SEE-HEAR. A FLUORESCING GARMENT. MEASURING STAND. THE SKIAMETER. HOW TO OUTLINE X-RAY SHADOWS ON TRACING PAPER. AUTHOR'S HEART OUTLINER.

The Fluoroscope.—Differing somewhat in the shape and size of its box and in the quality of its screen, the fluoroscope has been more or less indifferently used, and opinions of its value have been variously expressed. It will be educational to note a few of them before considering technique:

"Edison took advantage of the hint given by Professor Roentgen and devised the *fluoroscope*, and in so doing gave to the world one of the most important adjuncts to the X-rays themselves. Much has been written of the photographic applications of X-rays, but the fluoroscope has not received the attention its importance deserves. With this device we have a speedy means of approximately locating opaque foreign bodies in any region of the human economy if our apparatus is but sufficiently powerful to excite the tube to the necessary degree. Instead of being limited to the single view of a skiagraph we may examine our patient in any position, determine with great certainty the presence and nearly the position of bullet, needle, metal, or glass and gain considerable intelligence before operating. Obscure fractures and dislocations are determined, even though the œdema of the soft parts is so great as to prevent an exact diagnosis by other methods. Exostosis or congenital malformations can be detected at once, and their removal or correction facilitated. Beyond its aid in diagnosis the fluoroscope is a well-nigh indispensable aid in operating, for by covering the instrument with a sterilized towel we can *watch the steps of the operation* in removing foreign bodies or verify their absence. Indeed, if the object cannot be readily found, and we all are aware how elusive needles and shot can be, we can follow our instruments as they penetrate the tissues and observe their proximity to the body sought.

"As a means of medical diagnosis . . . dependent upon their location . . . some of the denser tumors cast darker shadows than the surrounding tissues. Tubercular or syphilitic osteitis is revealed, showing either the rarefied areas incident to the disease, or the blurred and irregular outline of the bones, a lack of the usual clear-cut, well-defined shadows. In the examination of the thorax . . . the fluoroscope is of infinite service, as also in the detection of fractures of the ribs. A few cases will illustrate the surgical adaptability of this convenient instrument:

"Mr. F. A case of suspected rheumatism. Fluoroscope revealed small bullet in the knee-joint.

"Mr. B. Was shot in left foot and great toe amputated. Discharging sinus persisted instead of foot healing. Fluoroscope revealed fracture of second and third metatarsal bones and five remaining shot.

"Mr. S. Was shot in elbow and bullet supposed to be imbedded. Fluoroscope proved its absence. None of the delay of a radiograph required.

"Mr. K. Tumor in lower third of femur. Fluoroscope revealed bone shading off into tumor. Diagnosis, Osteo-sarcoma. Amputated at hip-joint. Microscope verified diagnosis.

"W. H. Fluoroscope revealed old backward dislocation of radius and ulna, fracture of olecranon, and joint capsule filled with adhesions. Operated.

"Mr. M. Right hand pinched in coupling cars. Cellulitis and swelling so great as to prevent diagnosis of condition of bones. Fluoroscope revealed fracture of third metacarpal bone at middle of shaft, and partial crush of head of the bone.

"M. S., age seven. Hand puffed badly; last two fingers flexed and numb. Two weeks previous the child ran a needle into the palm of her hand and it broke off. Fluoroscope revealed it, and incising with instruments under the fluoroscope, it was quickly removed.

"Child, sixteen months old. Five days previous swallowed safety-pin. Fluoroscope showed the pin in ascending colon, open, but pointing the right way. Refused to operate, holding that if it had gone so far it would go farther. It was passed the next day.

"G. C. D. Chip of steel imbedded in the heavy muscles of calf. Physician enlarged entrance but failed to find chip. Fluoroscope revealed it at once, and under it I introduced forceps into the wound, watched them grasp the piece of steel, and removed same promptly.

"Mrs. R. Fluoroscope revealed sarcoma of right shoulder so extensive as to advise against operation.

"Miss S. Needle in hand. Removed under fluoroscope.

"Operations in three of these cases were done with the room perfectly dark, simply using the fluoroscope as a guide. The fluoroscope also supplies knowledge as to whether a radiograph is needed or not. While great proficiency in reading its shadows is a matter of some experience, yet even a novice can diagnose many cases with it." (Law.)

"Boy, five years old, emaciated, nervous, pain after eating, with several small hemorrhages in past three weeks; profuse hemorrhage day previous; poor appetite and afraid to eat on account of pain. Seventeen months previous had swallowed book-case key. Gave no trouble for twelve months but now threatened life. Fluoroscope readily revealed the key. Later introduced spiral forceps into œsophagus under anæsthetic. With fluoroscope over stomach found forceps were two inches too short. Shifted table, bringing head down, and, by manipulations with hand on abdomen, finally moved key up to forceps and engaged it. At length withdrew it, after which a free hemorrhage followed. Under careful treatment boy recovered. The fluoroscope was the means of success in directing the key. The recovered key was three inches long and so corroded that the handle was no thicker than a sheet of paper. The tongue was nearly rusted off. The extremity made sharp, ragged edges. Had the key remained it would have soon killed the child, either from inanition or inflammation, or from recurring hemorrhages, as the sharp points would have increased in number by corrosion." (Arp.)

"The fluoroscope is an accurate agent for corroborating and extending diagnosis made by the ordinary methods. It is capable of demonstrating foci of tubercular infection earlier than they can be distinguished by the ear. It shows either unilateral or bilateral enlargement of the heart and all displacements of that organ. Emphysema, asthma, pleurisy, hydropneumothorax, hydrothorax, and pneumonia, are all easily recognized and their limits demonstrated. In pneumonia it has been claimed that a more certain prognosis may be assured by the use of the fluoroscope. Thoracic aneurisms are recognizable in their early stages. Considerable practice is necessary before the eye can appreciate perfectly the fine differences of shade and outline." (Stubbert.)

"In pleuritic effusions the fluoroscope shows the displacement of the liquid as the patient assumes different positions, and with the action of the diaphragm. Purulent effusions seem less opaque than serous, but its principal value consists in the information it affords as to the condition of the lungs above the effusion. It reveals bacillary lesions and has a great prognostic value." (Bergonie.)

"The fluoroscope gives a better assurance that the lungs are in a healthy condition than other methods. It gives earlier evidence of lung disease and more accurate information concerning its extent. The heart may be outlined more accurately than has been hitherto possible." (Williams.)

"For a preliminary and superficial examination the fluoroscope is indeed invaluable. For examining those organs which should be studied while in motion—for instance, for observing the mechanism

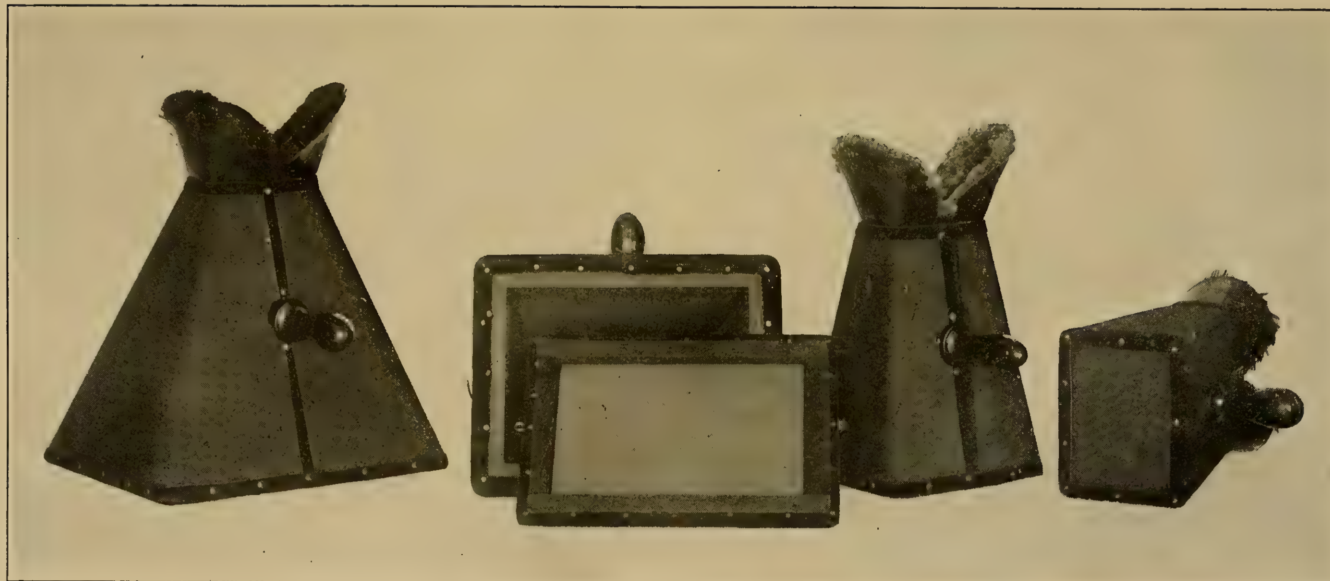


Plate 25.—Showing practical sizes of Fluoroscopes for regular use. One shows the removable screen detached. The screen can be used without the box when desired, and the box can be separately used for the examination of negatives as described in section on reading negatives. The set here pictured show the four sizes belonging to the author.

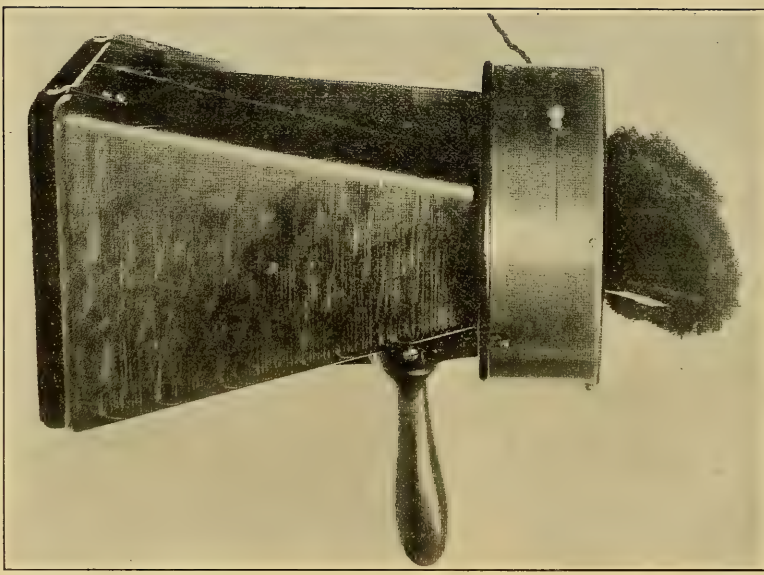


Plate 26.—Showing a projected Stereo-fluoroscope with rotating shutter operated by small independent motor. It aims to improve upon the earlier pattern of Davidson, which was not freely movable. At least three ingenious workers are busy at the problem of a practical Stereo-fluoroscope, and it is probable that in the near future this much-needed instrument will be born.

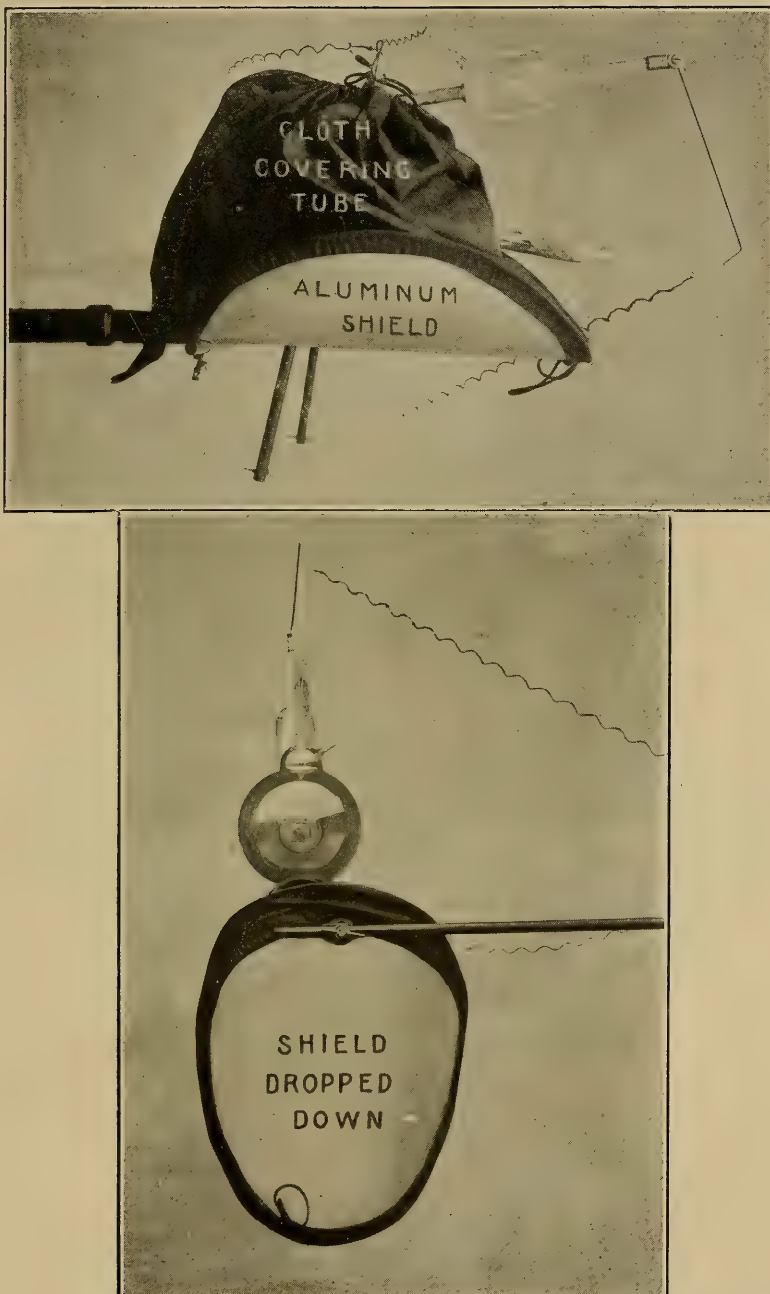


PLATE 27.—This plate makes clear the device suggested by Dr. Pfahler for darkening the tube. In the upper figure the main bulb of the tube is within the hood, and in action throws the rays down or out through the aluminum shield. The small auxiliary bulb seen out of the hood is the vacuum regulator. In the lower figure the hood is dropped to expose the tube.

PLATE 28.—Fluoroscopic Technics. This Instruction Plate shows the casual method of inspection in common use. Do not expect to determine a fine diagnosis of obscure thoracic conditions with the patient fully clothed and by the off-hand glance made in haste by rapidly turning the man around. In this way there is no adjustment of the axis of the rays, or the distance of the tube, and the position of the screen, except such as result from guesswork. Note also that with the arm down and the fluoroscope as placed in the plate the scapula casts a dark shadow over the lung tissue and prevents clear examination of the area. The relative positions of tube, patient, and screen in this picture are, however, much nearer correct than many employed in general practice.

of joints, the thoracic organs—fluoroscopy is the reigning method. But the fluorescing impressions, succeeding each other rapidly, are apt to blur in the eye if the features of the lesion are not distinctly marked, while fixation on a photographic plate gives all the details exactly. Therefore the fluoroscope should be used in fractures as a preliminary procedure only. It calls attention to the seat of the fracture, and determines the best position of the limb for the photographic posture. Especially in joint-fractures it will select the angle of flexion in which the injured portion can be brought out best on the plate." (Beck.)

The flexibility of the fluoroscope as an examining instrument is beautifully illustrated by a case of Dunn's. A six-year-old girl had swallowed a brass rivet seven months before. The physician believed the rivet had passed into the stomach and had caused no harm, but when brought to the surgeon the child was unable to swallow anything except liquids, and was almost in a moribund condition. The mind can hardly conceive of attempting to trace the rivet in the human body and to locate the proper place for a surgical incision before the discovery of X-rays. What took place with X-rays was as follows: "I placed the patient in front of the tube and with my fluoroscope I searched the stomach and the intestines for the rivet. At a glance I could see that it was not there. Passing from the abdominal region up over the thorax with the fluoroscope, I could see nothing but heart, liver, ribs, and spine until I reached the cervical region; there I saw the rivet lying behind the larynx. Placing my hand upon the neck immediately over the rivet, and making alternate pressure from side to side, I could *see* the rivet gliding under my finger between the larynx and the cervical vertebræ."

These early observations of the function and value of the fluoroscope have passed into accepted truisms.

With the true expert there can be no controversy between the function of the fluoroscope and radiograph, nor will he be in doubt as to when to use one or the other, or both. Some writers of less wide experience have asserted that the fluoroscope was nearly useless save for observing a tube and that all practical work should be done with the negative. On the other hand, equally narrow observers have repudiated the radiograph and declared that the fluoroscope would eventually be the sole instrument employed. Neither of these views is correct. A photographic plate and a fluoroscope are by no means interchangeable instruments for diagnostic examinations, and the place of each is as clearly defined in practical work as percussion and auscultation. The following communication will, however, be instructive to the beginner, as setting forth a practical argument which too many workers overlook:

"Dr. ——— says that *at least two* skiagraphs of suspected fractures should be taken, or the fracture may not be apparent. But even this may be insufficient. Four good, clear skiagraphs were taken of an imperfectly united tibia, before the line of separation, due to a band of fibrous tissue, was evident. A boy exhibited signs of recent fracture of the tibia. On fluoroscopic examination, a long, oblique fracture was visible, but only when the leg and tube were held in just a certain position. A deflection of ten degrees in any direction completely hid the line of separation from view. Apparently the periosteum, intact in places, held the fragments close together. In most fractures that have come under our observation, the fluoroscope is better as a means of diagnosis than the plate. The relative position of tube, patient, and fluoroscope can be easily and rapidly changed, securing in ten minutes a view from every possible angle, an absolute necessity in some cases, as in those cited above. It is impossible to say off-hand which angle will show the condition the best, and an experienced fluoroscopist can derive fresh information from every position of the tube. To secure the same thoroughness by plates would require hours instead of minutes, and dollars instead of cents. Bone being so much denser than the surrounding structures, the superior delicacy of the plate is usually not needed, excepting about the pelvis. In these and a few other cases skiagraphs are necessary, but in ninety-nine out of a hundred fractures the fluoroscope not only is easier, quicker, and cheaper than the plate, but it gives far more definite information." (Dr. R———.)

Selection and Care.—The box of the fluoroscope is usually a rigid frame, but some have been made with collapsible sides. For ordinary office use the rigid box is preferable. But it should be light, neat, and workman-like. A clumsy, rudely made box is not so satisfactory to the hand employing it. The screen in its frame is now made detachable from the rest of the box when desired. The combination of box and detachable screen affords the widest range of usefulness to the instrument.

In general practice the surgeon should have two sizes; a small one for the critical examination of very small areas from which it is desirable to exclude all surrounding fluorescence from the eyes, and one of medium size for every other use. Very large screens may occasionally serve a special purpose but will rarely be required in private practice. Some have been made as large as the human body.

At the present time all fine fluoroscopes have screens of platinocyanide of barium, which yield a much greater detail of definition than was furnished by tungstate of calcium. The best quality of these screens shows little tendency to deteriorate with time. Improved processes of manufacture have conquered many of the difficulties of earlier days and now provide us with a beautiful and reliable instrument.

Part of the excellent preservation of fluoroscopes will depend on the care given them by the surgeon. When not in use a soft cloth or tissue-paper should be stuffed in the top to keep out all floating dust, and they should be kept in a dark closet without dampness. If exposed to dampness during a wet season the backing (vellum or cardboard) of the screen will warp, and in shrinking again will in time injure the coating. Avoid this by a uniform dryness.

Correct Fluoroscopy.—Let us now abandon the careless use of the fluoroscope and begin the practice of accurate methods. The essentials of correct observation by means of this instrument are:

1. The observer's eyes must be closely pressed within the opening of the fluoroscope so as to exclude all external light, and the retina must be allowed time to alter from normal to a state adapted to the dark.

2. The base of the fluoroscope must be firmly pressed to the closest possible contact with the part to be examined.

3. The fluoroscope, the patient, and the active tube must be so placed in relation to each other that a straight line drawn through the part and to the focus point of the X-rays will make a perpendicular with the base of the screen at its centre. The parts will then show without distortion of the shadows.

4. The current exciting the tube must be adjusted to give the degree of X-radiance needed for the particular purpose of the examination.

5. The density and relation of the shadows must be systematically shifted till the eye best catches what it looks for in the case. This is usually done by altering the distance between the patient and the tube so that the penetration required is found by preliminary tests, and the examination is then completed at this distance. With the left hand press the part toward the screen while pressure against the screen keeps it firmly in contact with the tissues, so that in all tests of distance the operator, fluoroscope, and patient will preserve a unity of movement coinciding with the axis of the rays. When this is done the eye deals with right-angled shadows and not with the random distortions which have caused so much distrust of X-rays.

Do not tilt the fluoroscope up or down, or to the right or left. Do not let it move from the field of the rays to which it has been adjusted without also squaring the base of the fluoroscope with the axis of the new field. Neglect of this is the cause of most of the distortion that occurs in these examinations. Refer to your Divergence Chart and note how a true relation of parts can be obtained at any arc of the hemisphere of radiance provided that the plane of the screen is turned to the line of the central ray so as to form a right-angle with it.

The main uses of the fluoroscope are:

1. To enable us to make observations upon the actions of tubes, either for testing them or to watch their working during an exposure of a plate.

2. To enable us to obtain preliminary knowledge as to the need of a radiograph and the field of exposure.

3. Such general purposes of diagnostic examinations as come within its scope as set forth in these chapters.

4. To not only detect but to approximately locate foreign bodies when these are opaque to the rays and so situated that the eye can see them on the screen. Localization is treated of under its proper head, and the important matter of so-called " X-ray fallacies " will be considered in our study of " distortion."

The researches of a French scientist show that there is an enormous difference between a normal retina and a retina not adapted to fluoroscopic work. They also show the almost incredible increase of sensibility obtained by a few minutes closure in a dark room preparatory to examinations. Ten minutes thus spent increases the retinal sensibility from fifty to a hundred fold. Twenty minutes in a dark rooom increases the sensibility nearly 200 times as compared with bright daylight. But the ability to distinguish form and detail is less. However luminous the fluorescing screen may be it is inferior to full light, and hence the eye cannot derive from the increase in sensibility an advantage equal to its loss of visual activity in observing shadows under the conditions of fluoroscopic work.

The photographic film is not subject to this drawback and its impressions are cumulative, hence in respect to definition its capabilities are greater than those of the eye can ever be. The capacity of the normal eye under favorable conditions is proportioned to the opulence and steadiness of the X-ray discharge, and the mere quality of *penetration* without richness of quantity does not supply the eye with what it needs for diagnostic examinations.

The conditions required for the highest degree of visual activity and retinal sensitiveness combined are:

1. A heavy exciting current.

2. An interrupter that works the tube without flickering of the light.

3. An opulent generation of rays. (Rich in quantity.)
4. The exclusion of all other light from the eyes.
5. A high-class fluoroscope giving fine definition.
6. A tube that focuses correctly for sharp shadows.

Without a proper tube the best of fluoroscopes is at a disadvantage. To lessen time needed to alter eyes for fine fluoroscopy in dark room wear smoked spectacles during the last ten minutes of preliminary work if convenient to do so.

The Open Fluorescing Screen.—It has been claimed that in making long visual examinations (or many of them) the use of the regulation pyramidal box to exclude the light is fatiguing to the eyes because they then work in a confined and warm atmosphere at an arbitrary accommodation, and are required frequently to adjust themselves to variations in the light caused by removing the fluoroscope at intervals and resuming it again. This strain is greatest when the examinations are being made in daylight or an undarkened room. Moreover, all eyes do not focus at the depth of the box, and hence the arbitrary distance is another cause of strain. The box also is an inconvenience in the process of tracing records of the heart, movements of the diaphragm, and local shadows anywhere. Yet the boxed fluoroscope is an indispensable instrument in its entirety, and possesses advantages for which there is no substitute.

On the other hand, an *open* screen has certain advantages for selected kinds of work, and permits every eye to focus at its preferred distance from the shadow to be examined. It offers facility for tracing shadows which the box bars, but as it does not supply its own darkness it cannot be well used in a light room. Yet, as both the complete box and the separate screen have important uses, they should both be supplied in the one instrument. This has been done at the author's suggestion since the summer of 1898 by the maker of the original Edison fluoroscope, the framed screen of which is removable from the box at will by a set of hooks and eyes.

Specialists whose work falls in a routine line and who wish only the screen, can have one of preferred size framed and mounted on a standard adjustable to various positions. Such a mounted screen is shown in the illustration of the "skiameter" kindly furnished by Dr. Crane.

Darkening the X-Ray Operating-Room.—While the American fluoroscope is admirably designed to enable the operator to examine patients in ordinary light, yet no worker will fail to desire a means of making the room dark *at any time he wishes.* Not only are there certain advantages in a large unmounted screen, especially when tracings are desired, but many reasons make the command of darkness a necessity. Wooden shutters and holland shades have drawbacks. The best method is to fit black felt light-proof curtains on a frame larger than the window, and rolling up and down in a U-shaped groove so as to exclude all stray rays. Without this convenience of artificial darkness at command, it will be almost impossible to do general X-ray work with satisfaction. Few operators realize the difference between using the fluoroscope casually with no reference to the effect of light upon the eye, and using it with systematic care to adapt the eye to the slightest deviation from total darkness. The eye turning to the fluorescing screen from a bright light will see only the major contrasts; eyes dilated by preparation in the dark will take in details with much greater amplitude.

If for any reason shades are not feasible the operator may then construct an interior "dark-tent" around his apparatus, and shut out the light from a part of his office in the following manner. Secure firmly to the floor at each corner of the space required by the coil and patient an upright post seven feet high. Frame them at the top by cross-bars. Cover the sides and roof with light-proof black cloth, leaving a curtained entrance in front. A small office is usually darkened without much difficulty, but there still remains for consideration in fine work the exclusion of the local luminosity from the Crookes tube. There are various ways of treating this.

Black Varnish for Tube.—With a suitable brush paint a rather thick coat of black asphaltum varnish over all the glass surface of a selected tube except an observation space in the unlighted back half of the bulb. It will require some care to lay the varnish smoothly over the area fronting the focus, so that when lit up it will not let light through in streaks. For three years one of my early tubes did its work within a coat of this varnish. It did not lessen its efficiency in the least. The varnish did not interfere with either penetration or definition, and is readily applied by anyone.

A student finally broke this fine tube by touching it with a heavy gold ring while it was in action.

Box-Covered Tube-Holder.—Instead of simply throwing a black-silk sheet over the patient and tube and the examiner's head, something as a photographer covers his head and camera, the tube can be inclosed in a box which will exclude either all luminous effects or let light only through the small opening of a diaphragm. This box idea is incorporated in a tube-holder made by an Eastern manufacturer of X-ray apparatus.

Dark Chamber for Tube and Shield for Prevention of X-Ray Burns.—"For some time past the interposition of an aluminum shield grounded by a wire to the gas- or water-pipe, has been recommended. I wish here to present briefly a simple and convenient method of applying this principle, which may be of interest to those doing much work in this line. This method with a little modification can be applied to any form of tube-holder.

"It consists of a shield made from a sheet of the thinnest aluminum, cut circular, ten inches in diameter, the cost of which is trifling. A hole one-half inch in diameter is cut about an inch from the edge, and passed over the clamp that grasps the horizontal arm of the stand. The washer, having been filed sufficiently to allow for the thickness of the aluminum, is replaced and the shield fastened in the upright position in front of the tube. The shield may be bent about the tube, as seen in the Instruction Plate No. 27.

"It will now keep its relative position no matter how the tube is adjusted, and needs no further attention from the operator. Being attached to metal the stand itself needs only to be grounded. The shield will thus always be in use to protect the patient.

"Should it be desired to use the tube for therapeutic purposes, the thumb-screw is loosened and the shield allowed to drop downward, which only requires a few seconds.

"For class demonstrations the mounted fluorescent screen offers advantages over the fluoroscope, as it enables a number to see the same object at the same time, and thus permits the demonstrator to point out the interpretation of the different shadows. Its use, however, requires a dark room. In addition, the luminosity of the tube may be excluded by attaching a piece of thin, very tight mesh black silk to the edge of the shield, and bagging it over the tube by means of a draw-string. The whole arrangement is so simple, convenient, and inexpensive that I present it to the profession with the hope that it will give others equal satisfaction." (Pfahler.)

Rubber Jacket.—Another device for protecting the operator's eyes from the luminosity of the tube has been mentioned by Price, as follows:

"I must speak here of one addition I have made to tubes which is different from anything I have seen or heard of. It is for screening all luminous rays from the tube, while allowing the X-rays to pass. It consists of a jacket of unvulcanized dental rubber. I use the red rubber (which is opaque to the X-rays) for all parts except where the rays are emitted, where I use a window of black rubber, through which the X-rays pass unobstructed. This jacketed tube is then adapted for making fluoroscopic examinations in total darkness. It works to perfection."

Operators whose work does not require them to darken the tube except on rare occasions will find it a simple and useful device to throw a small square of thin black silk over the tube, when desired. The attraction of the current will hold it in close contact with the tube. It may be thrown on and snatched off at will while the tube is in action without a second's delay. The box inclosing the tube, the diaphragm, a coat of black varnish on the tube, the silk bag, and the loose square of silk as above mentioned, as well as the rubber jacket, are all efficient means of excluding the phosphorescence of the

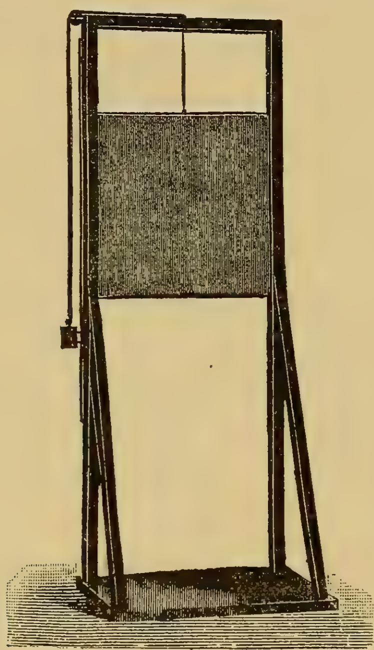


FIG. 9.—Sliding screen to shield eyes from light of tube in fluoroscopic work. The weight on the cord balances the screen at any point wished. Simply stand the frame on the floor in front of the tube, raise the screen to hide the light and pose the patient in front of the screen.

tube-wall, which must be kept out of the eye for the finest fluoroscopic work.

Light Screen for Continuous Fluoroscopy.—Make two upright posts five feet high and nail them on a base-board two feet apart, with a cross-bar at the top. Projecting backward from the top nail two light strips of wood a foot long, and complete them with a strip across their ends. Tack between the strips and posts of this frame a sheet of black paper similar to the inside envelope-wrapper of X-ray plates and the device is ready for use. If the base-board is made so that the patient stands or sits on it during the examination the frame will stand securely without risk of being pressed back upon the tube.

A variation in construction can be made. Between the posts fit a thin sheet of vulcanite, such as is used over the front of a plate-holder, in a frame which will slide up and down as desired. Balance this with a counterpoise weight. It cuts out the light in the direct path from the eyes to the tube when arranged at the proper level.

In practice simply place the frame between the patient and tube and as near the tube as the current will permit. The first design will cut out light from the top as well as from the direct path, and shields the eyes to a much greater extent than the smaller screen. It can be made at home for a few cents and a little trouble, and for one who makes regular use of the fluoroscope, as, for instance, in pulmonary examinations, it will be found invaluable.

The Stereoscopic Fluoroscope consists of a fluorescent screen illuminated by two tubes which are lighted alternately. A rotating disc with appropriately placed slots eclipses each eye alternately. This works synchronously with the action of the tubes. Each eye sees the shadow cast by one tube. A stereoscopic image is thus cast on the screen, the movements of the shutter being sufficiently rapid to give a continuous illumination of the screen. The general localization of a foreign body is thus greatly simplified and the nature of a fracture can be seen at once.

Several inventive operators have devoted much time and thought to the improvement of this device to a practical and easily worked convenience. With a perfected instrument of this kind almost all that has been written of X-ray fallacies, and many theories as to the medico-legal status of X-rays would lose weight, for the convincing view of a body stereoscopically seen by the eye is altogether a different matter from a shadow without thickness.

The importance of a readily operated stereoscopic-fluoroscope cannot well be over-estimated. Only a trained expert can grasp the full significance of such an instrument in practice. One of the difficulties has been to get two tubes that would work equally. The fine regulating devices entering the market as this is written ought to facilitate the working of the now all but practical stereo-fluoroscope. It is a great mark for coming X-ray inventors. *No other one instrument will give such value to Roentgen's discovery, for it will carry binocular vision directly into the tissues which now only appear on the screen in a plane shadow. The achievement of the third dimension will entirely revolutionize X-ray diagnosis.* With this too brief mention we leave a great subject to the developments of the near future.

The "See-Hear."—A combination stethoscope-fluoroscope is called the see-hear. It is designed so that while the ear is ausculting the heart or lungs the eye may be inspecting the same regions. The originator's remarks are as follows:

"The instrument contained two principles new in stethoscopes; one a sound chamber, the other a fluorescent screen in connection with a sound chamber. The former has since been adopted in one of the stethoscopes in common use. The latter awaits recognition. As shown in the figure, the fluorescent screen is about seven centimetres in diameter. The sound chamber is one centimetre in depth, the wall toward the patient being of thin hard rubber or other radiable ma-

Fig. 10.—The See-Hear. One form of combined fluoroscope and stethoscope enabling the operator to see the movements of the heart while listening to its sounds. Another form makes use of an open mounted screen with a sound chamber added to the fluorescing base.

terial. There certainly is an advantage in hearing the sounds in the chest while the organs are under inspection, and, as I have designed comparatively cheap apparatus, giving plenty of X-light of suitable quality, such an instrument as the see-hear should be used extensively. Perhaps in the form now shown it may be appreciated."

A Fluorescing Garment.—We find the following note in a medical journal: "Von Ziemssen, improving on the method of direct examination by means of the fluoroscope, clothed the patient in a closely fitting covering impregnated with a fluorescent compound. In this way, the position and movements of the viscera can be comfortably observed."

A Measuring Stand and Examining Frame.—To aid in measuring the position and sides of internal parts or foreign bodies, the measuring stand of Hoffmann consists of a square frame which can be moved

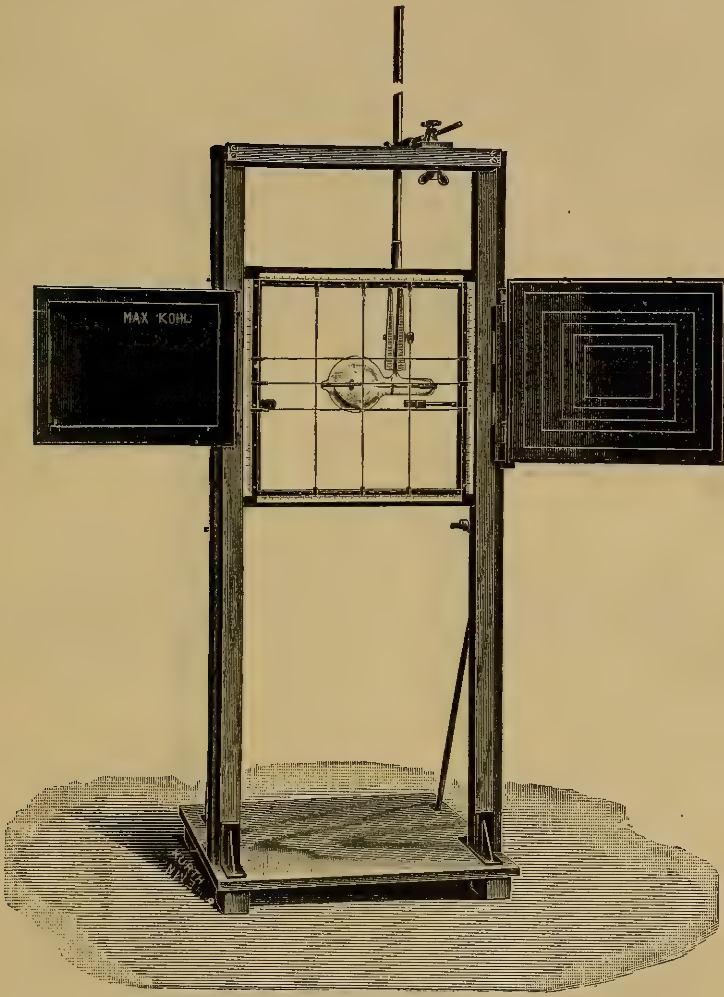


Fig. 11.—Measuring Stand for X-Ray Examinations Designed by Dr. Hoffmann. The patient sits behind the wires and the operator views from the front. At the left is seen the mounted screen to swing round in front of the patient. On the right is a plate-holder for making a radiograph of the part after the fluoroscopic inspection.

up and down between two posts. These upright supports are connected at the top by a cross-bar, and are mounted on a substantial platform upon which the subject stands or is seated on a stool. The weight of the patient thus anchors the apparatus firmly on the floor.

"The movable frame is mounted with brass side-pieces and is adjustable to any height of the stand. The movable frame is then fitted with three vertical and three horizontal metal cross-bars like stout knitting-needles. These are also movable, and the edges of the

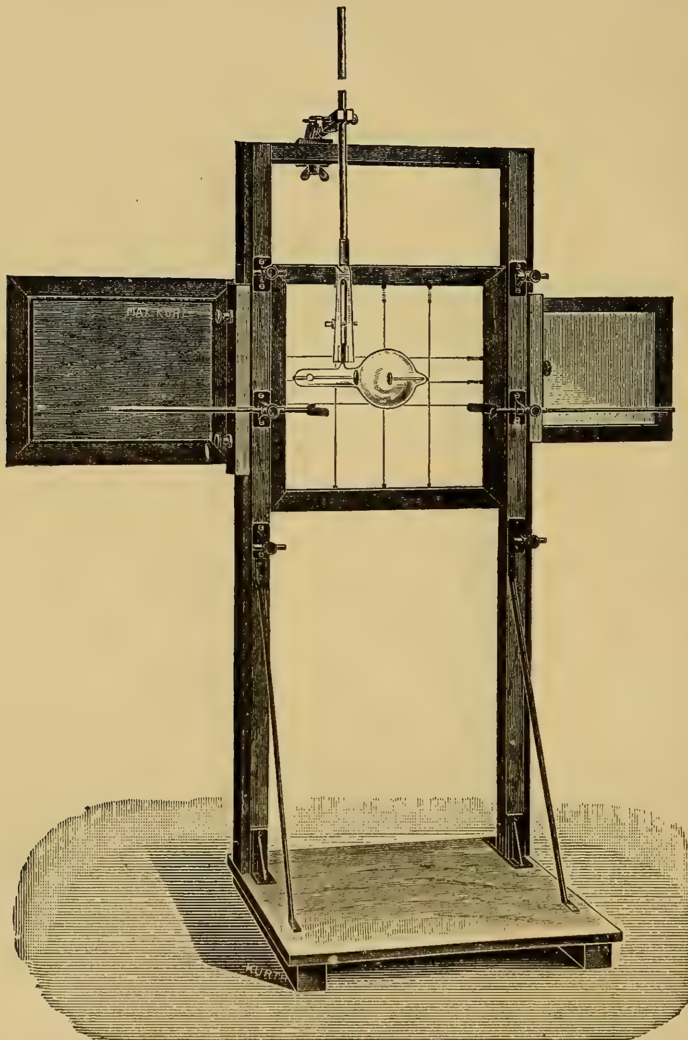


FIG. 12.—Back view of Dr. Hoffmann's measuring stand for X-ray examinations.

frame are marked with a millimetre scale so that the distance separating the parallel wires can be read. One of the upright posts of the stand is provided with three rests similar to the head-rest used by photographers to aid in holding the patient in position. At the sides of the stand are two accessory frames on hinges, one for receiving a plate if a radiograph is to be made and the other to hold the fluorescent screen if visual inspection is desired. Operators using the American fluoroscope may detach the screen from the box and use it with this stand, or they may use the fluoroscope in the usual manner. The cross-bar at the top of the stand carries a tube-holder with an adjustable arm, which permits the tube to be placed at any desired height or position.

"For practical use seat the patient in the required position on the base of the stand. Adjust the measuring frame to the height of the field of the part to be examined; for instance, the thorax; adjust the tube at the desired level two feet distant from the centre of the movable frame. Insert the fluorescent screen in the frame designed to hold it, and swing it on its hinges around against the cross wires. When ready for the examination start the tube into action, have the patient press closely up in contact with the frame and screen, and proceed in the usual manner. Both hands are at liberty, and the cross wires may be set at any desired point.

"It is obvious that by approaching two horizontal rods and two vertical rods to the margin of shadow that an organ, the heart, for instance, can be practically framed. If a third wire is first fixed as a landmark in relation to a definite point on the patient, as, for instance, the nipple, the position and size of the heart is practically mapped out and can be read upon the millimetre scale. The same principle can be employed upon a radiograph. A bullet or small object can be made to register at the angle of two cross-bars. The skilled operator will, of course, take into account the thickness of the patient, the distance of the object examined from the screen, and the enlargement of the shadow caused by the divergence of the rays."

The illustration of this apparatus shows the tube-holder attached to the cross-bar of the stand. This necessitates a new adjustment of the tube for every movement of the wired frame. A great improvement would be made by attaching the arm supporting the tube to the top of the movable frame, so that when once adjusted it would follow each alteration of the field automatically. As this is a useful device, the American physician who has one made to order may wisely modify the construction as above suggested. See also description of the author's localizer and examining frame.

The Skiameter.—This word has been applied to three different devices by different X-ray writers. It indicates a "shadow-measure," and has been taken out of the commonplace and lifted to scientific eminence by the labors of Dr. A. W. Crane, whose classical account of his instrument and its uses will now follow:

"The essential idea of a means of mensuration by which we may increase the delicacy of our observations and record more definitely their results, is the obscuration of one shadow by another which is superimposed. When a weak partial shadow is superimposed upon successively stronger shadows it becomes less and less definable until it is obliterated to the eye. At first it is reinforced, at the same time that its limits become less defined, but this reinforcement is less and less observable as the interfering shadow becomes denser. This principle explains why it is so difficult to see a hip-joint; the shadows of dense tissues are superimposed.

"Instructive experiments may be made with daylight or gas-light by folding a piece of paraffin paper so that it will present from one up to thirty-two or more layers. With some metallic object held between this paper and the light the gradations of partial shadows may be studied and the principle applied to X-ray examinations, for there is no essential difference in the behavior of the shadows. X-rays are singularly favorable to this method of shadow measurement, for they suffer no refraction, reflection, or diffraction.

"The skiameter devised for this purpose is simple in construction and principle. It is made by fastening strips of tin-foil upon strong cloth-covered pasteboard.

"This gives us an instrument made up of six notched and perforated bars of tin-foil, one metallic rod, and six equal interspaces.

"If now this *skiameter* is held in front of the fluorescing screen we see that we have a series of partial shadows of graduated densities. The tin-foil strip of two layers casts a heavier shadow than the strip of one layer. Five layers make a heavier shadow than the lesser layers. These are *partial* shadows because they do not entirely cut off the X-radiance. A knife-blade will cast a shadow upon the screen through any of the tin-foil bars, but not through the metal rod before the tin-foil, because the latter throws an *absolute* shadow. If a layer of tin-foil is interposed between the skiameter and the fluoroscope the smallest hole in the first bar becomes indistinguishable. If ten layers of the foil be interposed, the entire first bar becomes obliterated. If fifteen layers be interposed, the fifth bar is blotted out and only the metal rod can be discerned. The foil employed should be of such a thickness that the shadow of a single strip will be barely but plainly discernible just above the diaphragm during inspiration through a heavy man's chest, nine inches through. We have herein a method of measuring the density of a partial shadow by ascertaining how strong a known partial shadow it will obliterate. In the skiameter we have a series of partial shadows of known density.

"To measure any given pulmonary shadow, place the patient standing before an active Crookes tube. Hold the fluoroscope against the chest as usual, and hold the skiameter against the opposite side of the body. The Instruction Plates show the proper position of tube, skiameter, patient, fluoroscope, and examiner. (See Chapter XXXIV.)

"The shadows of the skiametric-bars are thus made to fall through the thorax upon the fluoroscent screen and are superimposed upon the shadows of the chest. Note the weakest bar and the smallest hole discernible in a given field. Compare the two sides of the chest. Pass the skiameter over the thorax in every position. If it is kept slightly moving to and fro a closer reading may be made, because the eye will

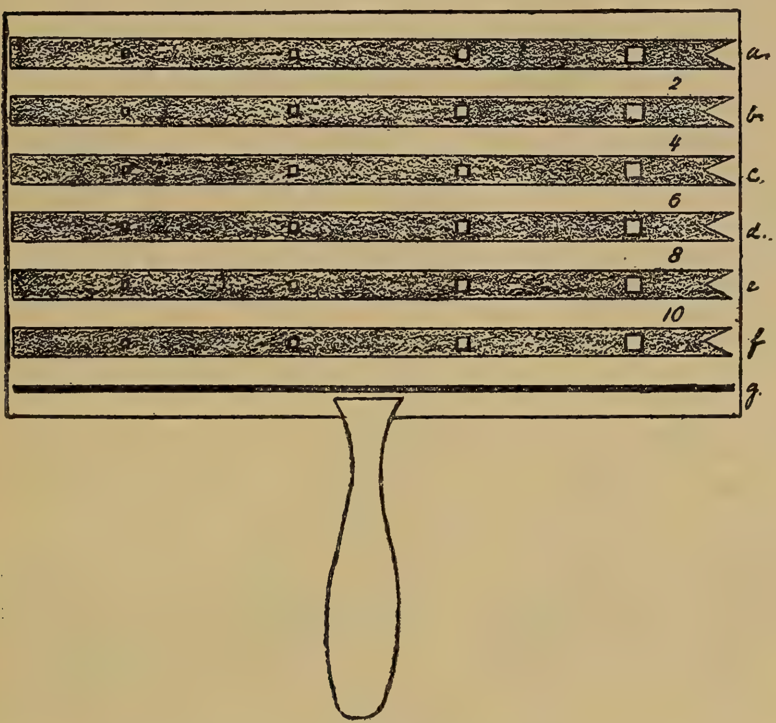


FIG. 13.—THE SKIAMETER OF CRANE.

Directions for making the Skiameter. Lay down six strips of tin-foil side by side, parallel with each other and separated by equal spaces. Make each strip and each space one cm. wide and ten inches long. Make the first strip of one layer of tin-foil, the second strip of two layers, the third strip of three layers, the fourth strip of four layers, the fifth strip of five layers, and the sixth strip of but *one* layer for contrast.

One cm. below the sixth strip and parallel to it fix a metal rod the size of a stout knitting-needle. In each strip cut a series of four small square holes equal distances apart. Make the holes run from 1 mm. to 4 mm. square and have the six series directly under each other in similar order in the strips of foil. Deeply notch the right end of each strip and fix wire figures (2, 4, 6, 8, 10,) in the successive interspaces near the notches. Add a handle and for protection paste a piece of thin muslin over the front surface. This completes the instrument and it is ready for use. See Chapter XXXIV. for photographs of uses.

perceive and appreciate a moving shadow better than a stationary one. The *holes* along the single strip are of great assistance. An infiltration which would escape the unaided eye may thus be observed and measured. The sixth strip of one layer lying between the metal rod and strip of five layers facilitates comparison. In practice it is found to be the most useful bar of the skiameter.

"*The tin-foil bar of one layer is the unit of measure.* If over any given thoracic area the examiner finds that the shadow of this bar is indistinguishable, while the shadow and holes of the next heavier bar can be seen, he has encountered a chest shadow of *one degree.* If the shadow, which will obscure a single strip of tin-foil, be taken as one degree, then the smallest hole in this strip may be taken as 0.2 of a degree, the next 0.4 of a degree, the next 0.6 of a degree, and the largest 0.' of a degree. The strip of two layers denotes *two* degrees, three layers denote *three degrees,* and so on. If a chest shadow is so dense that the shadow of the metal bar cannot be distinguished through it, then we have an absolute shadow.

"The *boundary* of shadows can be more clearly designated by the aid of the skiameter than without it. This is because superimposed shadows reinforce each other if their densities are not too greatly at variance. The shadows of the bars should run at right-angles to the margin of the shadow being examined. The eye can appreciate the difference in the skiametric shadows where they overlap the chest shadow more clearly than it can the difference between the chest shadows in disease and the normal lung-shadow. For this reason the skiameter is of real practical service in the general detection of pulmonary shadows even without any attempt at measurement. The two sides or parts of the same side may thus be rapidly compared.

"Whether or not the tube is producing exactly the same quantity and quality of X-rays in each examination with the skiameter is immaterial, because both skiametric and chest shadows are partial shadows and diminish or increase proportionately. The same explanation applies to differences in the distances of the patient from the tube. The difference in the thickness of different patients will make some little difference in the degree to which the shadows of the skiameter are magnified.

"The instrument may be used not only as a measure of density, but for linear mensuration. Each bar and interspace is one centimetre wide. One end of each bar is notched, and wire figures mark each interspace. For the latter purpose the skiameter is placed not on the distal surface of the body, but close against the fluoroscope so that the notched ends of the bar form *a centimetre scale* running across the field in front of the patient's body. *The apparent size of pulmonary consolidations, of cavities, of the heart, and the excursions of the diaphragm can thus be conveniently measured.* The difference in the position of the diaphragm in ordinary inspiration on the two sides may be measured by placing the skiameter so that the metal bar at the bottom is at right-angles to the spinal axis, and so that it marks the position of the lower diaphragm. Then the position of the other side may be read on the scale.

"The skiameter is an instrument designed for practical use in the fluoroscopic examination of office and hospital patients suffering from pulmonary diseases.

"In the absence of any special method of recording the results of these examinations the author suggests the use of Keen's clinical charts."

Plate 29.—Faulty Methods of Examination. Study these and avoid the obvious errors. In the upper figure see the slanting relation of the axis of the rays to the part under the photographic film. If the thorax is radiographed in this manner distortion will make the result useless. See our teachings on divergence and distortion. In the lower figure see how far from correct is the axis of the rays with the screen and patient as shown. These two illustrations teach "how not to do it" with great clearness. All such work is mere trifling with the scientific principles of technic and is unworthy of anybody.

PLATE 30.—Instruction Plate teaching use of author's Frame to examine any part of the head in the axis of the rays. The dotted lines on the exposed screen mark the axis at their intersecting point. The front and back markers shadow these lines on the screen and all parts of the head can be brought into this field of non-distortion.

PLATE. 31.—This plate illustrates the "Ortho-diagraph" of Dr. Moritz, "an apparatus designed to permit the accurate mapping out of internal organs without taking a picture." It aims to limit the screen observation to a diagnostic field through which only perpendicular rays pass, cutting out the slanting rays of side fields beyond the axis-centre. This is done by bringing certain lead marks into register when a simultaneous moving of both tube and screen fixed in the same frame brings each part of the body in successive view till the entire part is examined as desired. The outline of the heart, for instance, is thus seen in a series of continuous observations which keep it at the normal size without the enlargement caused by divergence. (A glance at the author's Divergence Chart will make clear the fact that the central-axis rays do not enlarge a shadow.)

With the patient on a table and both tube and screen fixed in exact relations to each other in a frame which can be shifted over the entire field of examination without losing the axis of the central rays the object is accomplished. The engraving shows another view of the apparatus. The principle involved is about the same as in the examining frame independently originated by the author and described in other plates. (Rebman, Ltd.)

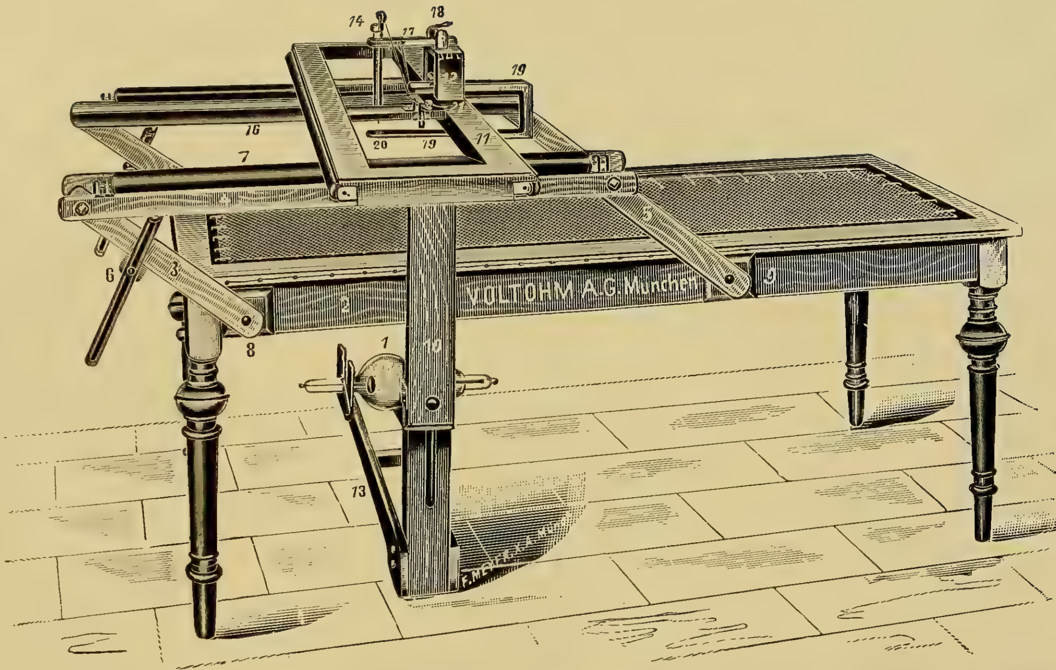


PLATE 32.—This figure shows the Ortho-diagraph in greater detail than in the preceding half-tone. Its adjustment on the operating-table, the position of the tube-carrier, and the fluorescent screen with movable markers are all made clear in this illustration.

How to Outline X-Ray Shadows on Tracing-Paper.—A tracing may often be valuable for record. Though most physicians have read of the method only with reference to the heart, yet many other records of great value can be made, as will now be taught. The regular fluoroscope cannot be used. An open screen mounted in its frame without the box is required. Then of small strips of wood make a frame which will just fit inside of the frame of the screen, and clamp fast the tracing-paper laid inside the screen. Ladies who do embroidery have a pair of rims to hold their canvas or linen on the stretch, and we apply the same idea to holding our tracing-paper. The screen must also be secured at a right-angle with the axis of the rays so as to leave both hands free, and the eyes must be protected from the light of the tube. Therefore:

Place the author's *examining frame* in position in front of the tube and suit it to the level of the part to be examined, as taught in section describing this device. (Chapter XXIII.) Lay the piece of transparent paper inside the fluorescing screen, and with the inner frame press it into close contact with the fluorescing surface and clamp it fast. Then clamp the screen on the examining frame as usual. Bring the part to be examined into the fixed field as taught, and start the tube into action. Shift the part for final adjustment of the shadows into the exact field outlined by the markers of the frame (which are previously placed as may be desired), and throw over the head a large black cloth so as to inclose the eyes, screen, and entire field of observation from outside light. The shadows will then plainly appear.

To avoid magnification keep the tube not less than twenty inches away for thin and medium parts, and thirty inches away for the trunk of the body. To secure the best degree of shadow regulate the tube to produce the correct degree of radiance.

Then with an ordinary lead-pencil trace the outlines on the paper. It is well to also trace in the lines of the markers to show the relations of the parts to the rays. When done stop the tube, remove the patient, unclamp the screen, take out the tracing-paper and write on it the notes of the examination. To record, preserve, and prepare for reference mount the tracing on white cardboard, which will make a white background for the tracing and bring the marks into plain relief.

The interference with the normal shadow-power of a screen by tracing-paper in front of it is not very great. It would cause some faint shadows to be lost, but with a well-darkened field of observation, obtained by the aid of a head-cloth, the operator can make records of surprising accuracy and value.

Author's Heart Outliner.—This device is designed especially to mark the margins of the heart on both skin and record-sheet without the difficulties and errors common to ordinary methods of tracing. In tracing an outline directly on the skin with a fluoroscope the screen must be lifted enough to let the crayon or pencil mark under it, and this causes some deviation of the line. To transfer the tracing later to a record blank is some trouble in addition. If an open screen is used and the tracing made on celluloid, glass, or paper (as many do it) there is some enlargement due to distance between the pencil and the body casting the shadow, and transference to the skin, if desired, is also some trouble. These difficulties are less to one who has a draughtsman's skill, but the novice finds them awkward. The author's device aims to eliminate the trouble. As most of the needs of tracing exact sizes and borders relate to the heart the following description will apply chiefly to this organ, but other sizes and shapes of the instrument can be made by any one. A set of large, medium, and small (three sizes) would cover all essential work.

At any tool shop have made a thin broad rim like the rim of a wheel, say, out of stiff sheet-brass three-sixteenths of an inch thick. Turn smooth and polish down. Make the rim nine inches across with its inside diameter eight inches. Take thirty-two narrow strips of thin spring steel (or any convenient metal) six inches long. Then channel one surface in radiating grooves to closely fit the metal strips so that each will stay firmly where directed by the operator.

Insert each strip in its groove and we have a wheel with flat radiating spokes, each of which can be moved from the rim to the centre and left stationary at any intermediate point. Every spoke will cast a shadow, and we are now ready to use the *outliner* to ascertain the exact size of a patient's heart *without magnification, distortion, or difficulty, and with a simplicity of technic not equalled by any other method.*

Strip the chest of the patient; level the focus of the tube with the author's examining frame (as taught), and at a suitable height for a sitting position; have the patient sit in the frame; clamp on the fluoroscope or open screen (whichever you prefer to use) and start the tube into action. Regulate the X-light dosage to give the clearest shadow of the heart, then slightly shift the patient so that one border of the heart will engage the marker of the frame. Slip the "Outliner" between the patient and the front of the frame and have the tissues hold it in place by close pressure. This border will then be exactly in the perpendicular axis of the rays coming through the body, and there can be no distortion or enlargement of any appreciable amount.

Keep the eyes in the fluoroscope to direct the strips, and with the convenient hand, right or left, according to the side of the heart engaged) successively push down strip after strip so that the tip of each stops just at the border of the heart shadow. When the margin engaged in the "marker" is outlined have the patient hold firmly the rim of the instrument while he shifts his body till you engage another border or section of border in the marker. Then push down other strips as before, and continue till all the visible free border of the organ is registered by the tips of the metal strips. Have the patient hold the rim steadily in position and slip out of the frame. Take any charcoal crayon, or dermal pencil, and run a line on the skin continuous with the margin indicated by the ends of the radiating spokes. To mark the record-sheet simply lay the Outliner on it and pencil the liner as indicated by the tips. The process is then complete.

As the outliner has been in close contact with the skin during the process of adjusting the strips, there has been no magnification added to that of the parts. As the fluoroscope is also in close contact with the tissues there is no such deviation as is caused by using it one or more inches from the tissues. As the borders marked in succession are each placed automatically in the axis of the rays by the examining frame there is no spread of the shadow such as is caused by diverging rays. The whole process being mechanically accurate, there is none of the uncertainty inseparable from all previously taught methods. It is more quickly done than any other method. The difficulties of transferring a tracing from celluloid to skin or from skin to paper are obviated. Any one can have the outliner made at home from the above directions.

To Compare Heart Size at Future Examinations.—For this purpose the Outliner is par excellence beyond all other crude attempts. Simply take out the original record blank, lay the outliner on the marked lines, shift the strips to conform, place the patient in the examining frame, and with the aid of the screen engage the heart in the space within the tips. Any alteration in size will be mechanically shown. The uncertainty of the troublesome measurements usually taught are obviated. The outliner is an advance in heart technics that revolutionizes X-ray examinations for size and position, for position is exactly shown and recorded at the same time the size is marked.

The same principles apply equally to measurements of tumors or other shadows which can be made out on the screen. For small work a rim with an opening four inches in diameter could be made, while larger work than we have here considered can be similarly lined out by having a rim big enough to take in the part.

CHAPTER XII

THE FUNCTION OF THE RADIOGRAPH

Dosage of X-Radiance for Radiography.

As the fluoroscope has its essential function to perform in X-ray examinations with the eye, so there are purposes for which the fixation of the image on a photographic plate is either a necessity or an advantage. Let us now note the function of the radiograph in surgery.

"It is the plate only which shows the details of the fracture exactly, and which permits the thorough study of the various features of the fracture-type. Its comparison with the normal skeleton will make the abnormalities evident at once, and will help the surgeon to a proper judgment of the case. And the value of the negative for future reference—sometimes for forensic purposes—should not be underestimated."

Briefly, and without multiplying authorities in a matter about which there is no real dispute, we may sum up the functions of X-ray photographs in a few words.

1. The negative makes a fixed record. It can be re-examined at any future time. Others can look at it, and it is original written evidence in the case.

2. The negative will show finer details and contrasts of shadow with fixed parts than can be noted by the eye.

These two factors of advantage have sufficed to carry the radiograph into every department of diagnostic X-ray work. On the other hand, it takes time and trouble, costs money for every plate, records but a single position or view, and cannot represent parts during functional movements. Also, the value of the radiograph depends on its quality and what it shows. Countless negatives fail to be worth anything, but a good negative reveals more than the eye can see on a screen in respect to anatomical definition and detail of parts at rest.

In his classical paper on nineteenth-century progress in the photographic art, Mr. Rockwood compares the limitations of the eye with the more microscopic capacity of the plate. He shows that in the matter of minute detail the camera can see better than the human eye, and the same principle holds good in X-ray photography. Signatures to wills have become so faded as to be illegible to the eye, and the impression on the sensitive plate has been clear and readable; eruptions have been revealed by the plate before they had developed to the eye; stellar photography discloses millions of stars in fields that were a blank to telescopic vision; and many similar examples point out to us the function of the radiograph.

The celebrated Wheatstone measured the duration of the electric spark as one twenty-four thousandth of a second. Modern "instantaneous" plates will record the writings of the electric-spark, but to the eye, which retains the light-impression of a spark for half a second, 12,000 separate waves appear as one. Rockwood beautifully illustrated this in his remarkable photographs of the vibrations of the telephonic diaphragm under transmitted speech. Two hundred and fifty-six of these microscopic vibrations would make their impression on the eye as one if they were deep enough to be seen at all, which they are not, and would give a stationary, fictitious image; but on the plate and under a powerful magnifying glass each position of the indicating points was separate and distinct. In X-ray inspection of a part not only does the eye receive its impressions *en masse*, but it looks directly *into* the light and thus exercises vision at some disadvantage. Details that might be well within the power of the eye to detect by reflected light are lost in the glow of the direct light in which all fluoroscopic inspections must be made, and in losing these finer details from the eye we lose much of the diagnostic value of X-ray vision. Gross discriminations can be made with the eye, but for distinct lines and contrasts we must first let the film take the impression, and then we can see it while preserving the retina from the general glow of the luminous screen. It is often remarked that a tube which shows very well with the fluoroscope may be very poor for photographic effects. This is a mistake arising from lack of reliable tests on the part of the observer.

When my window-and-shutter gauge of X-ray penetration was devised I was wholly unaware of Roentgen's experiments along similar lines, a translation of his paper not coming before me till seven months later. In the following language he confirms my own refutation of the popular belief that the same rays may have a low photographic efficiency while possessing a higher efficiency with the fluoroscope, and vice versa. A technical journal translates Professor Roentgen on this point as follows:

"Photographic results follow the fluorescent screen very closely, particularly with soft tubes; but with hard tubes the window number seemed a little lower than with a screen. When a hard and soft tube bring the two halves of the screen to the same brightness a photographic plate put in place of the screen is less affected by the rays from the hard tube. The latter go through the film, and will go through ninety-six films, and impress the last one while the first is scarcely over-exposed. For this special reason hard tubes require longer exposures, while very soft tubes need longer exposures on account of their feebler intensity."

This is satisfactory and correct under the conditions of Roentgen's tests, but as practical radiography can modify the conditions of scientific investigation the latter half of the above extract calls for a little interpretation lest it confuse the reader.

The discrimination made between rays from "hard" versus "soft" tubes must appear contradictory to the novice. The terms, hard and soft, are obscure, and, though they have come into too common use, they mean nothing definite unless qualified by considerable explanation and a statement of the dosage of the exciting current. In the second place, the slight difference in activity on plate versus screen, noted by Roentgen in his open test, is negligible in actual work directed by methods of approved practice. Lastly, the puzzling assertion that the most penetrating rays require a longer exposure, when the common experience is the contrary, evidently needs the interpretation that they require relatively more time to affect the film than would be computed by comparison with feebler rays. But the absolute exposure time is shorter and not longer, as the beginner might infer.

But Professor Roentgen dwells on other points of his investigations which throw important light on the use of the brass background advised by the author in another section. He says:

"In a tube in action X-rays come not only from the focus spot on the anode, but, more feebly, from the whole plate and a part of the wall of the tube. Even the air, when struck by the rays, sends out X-rays in all directions, and these rays are photographically active."

Herein lies the value of an opaque diaphragm and window, as elsewhere described, to shut off lateral extra-rays and assist to secure the highest refinement of radiographic definition. And, having cut off most of these fogging side rays, and noting that the direct rays of the highest penetrating efficiency go through ordinary plates without stopping quite long enough to exert the most rapid actinic action on the film, we have only to back the film with an artificial "stopper" and we accomplish two purposes at once; we check the fleeting rays so that possibly an enhanced "absorption" is secured, and by the impact of rays of high intensity, striking an impervious body nearly or quite at right-angles, we have a new creation of rays and a sharp reinforcing fluorescence on the film. Thus the primary fact that rays pass too easily through flexible films, such as Roentgen reports that he used in his tests, works out for greatly improved, instead of slower, results when we not only back the film with somewhat retarding glass, and to this add completely opaque metal. So far has the general reader ignored these practical facts that they will doubtless seem new to many.

But besides the general question of the function of the radiograph as compared with the fluoroscopic ocular view, we consider in each case the function of the individual radiograph—the purpose for which the negative was taken. Refinements of technic now divide radiographs into two important and quite distinct classes, the function of which is materially different. Few beginners are aware of this.

The different functions of radiographs primarily grow out of the individual requirements of diagnosis, one being simply to show presence or absence of a foreign body; another to exactly determine its location or size; another to show anatomical relationships; another to define details of structure; another to contrast densities; another to discover the fact of an alteration from normal; another to illustrate the normal; still another to compare the normal with the pathological; and so on, as will appear throughout subsequent chapters of this book, but in this place we refer to two broad subdivisions of function as relating to:

1. *Momentary* exposures of parts having physiological movements.
2. Time-exposures of parts at rest.

Distinctions novel to the beginner are set forth with instructive fulness in the writings of Von Ziemssen and Professor Rieder, of Munich, whose authoritative X-ray work needs to be more widely known in this country. The great function of the almost instantaneous radiograph is to picture the thoracic organs, especially the heart, in a state as near as possible to rest, and imaged on the plate during *a single phase of respiration.* The exact method will be duly described later. The possibilities are of exceeding interest to internal medicine, and every reader who has noticed abstract references to such work will be instructed in this book exactly how to do it himself.

Dosage of X-Radiance for Radiography.—At all times it is well to have a liberal stock of tubes so that they can be used and rested in rotation, and thus remain long in working order instead of rapidly reaching too high a resistance. The proper way to obtain selected degrees of X-radiance for given work is to regulate the factors on which radiance depends. A single tube can thus be adjusted to any one of a dozen degrees of action, and modern "regulating" devices have put the process on the simplest basis.

Granted, then, that we may regulate any proper tube to any desired intensity of radiance, let us see what are the requirements of practical work. It is not the therapeutic rule that the greater the dose of medicine the better the effect, and it is not the X-ray rule that the greater the intensity the better the radiograph. The "dose" must be adapted to produce the desired effect. Some effects result from a small dose of X-rays; some require a larger dose; some tax the utmost capacity of the apparatus to secure them. In each case the best result is obtained by a suitable penetration and richness of rays without much variation above or below what is needed.

The beginner will get the idea correctly from a simple test. Into a wooden box place a large leather bag containing a little assortment of bone, ivory, pearl, vulcanite, and metallic buttons. Start the tube into the feeblest action, and at three feet from the anode begin a fluoroscopic examination of the box and contents. Test the contrasts of shadow at each distance up to a single inch from the tube wall, and with a gradual increase of the current up to the maximum X-radiance. Note that a dosage which yields the best definition of the wood of the box and the leather of the bag has no penetrating effect at all on the dense metallic objects. When the dosage brings out the best detail of the bone buttons the wood is about lost. To pass light through the most dense contents the higher dosage obliterates all the fainter shadows that were best studied far below the maximum. A few minutes devoted to this study teaches that in radiography:

1. A small X-ray dosage will produce the least contrast between soft parts and contained bones or a bullet.

2. A high dosage will produce the most contrast between flesh and bones or bullets.

3. A short exposure with a high dosage and a long exposure with a low dosage do not produce equivalent results.

4. Rays of great penetration produce great contrasts between bodies of greatly different density, but not between bodies of slightly differing density.

5. Rays of medium penetration combined with great quantity produce the best contrast and definition between bodies of moderate difference in density.

6. Rays of great quantity produce the greatest amount of definition at all degrees of penetration.

7. Rays of great quantity act more intensely on the sensitive film than rays of the greatest penetration with less quantity.

8. A dosage that is high at a short distance is lower at a longer distance, and will be very low at a still farther distance from the plate.

9. Nothing in practical radiography calls for a very small dosage of X-rays.

10. *All* work is aided by the factor of *quantity*, and the factor which requires regulation in dosage is the *degree of penetration.*

As part of the dosage is always arbitrarily out of the operator's control and linked with the construction of the apparatus (especially the factor of quantity) do not try to learn from printed directions how to dose the tube, but *make tests of effects* by radiographing muscle organs within soft parts, thin bones within thin and thick parts, and thick bones in thick parts, and record as nearly as possible the dosage used. The author's gauge enables this to be exactly done.

On a plate lay a piece of one-fourth of an inch wood, six overlapping pieces of cardboard, and several layers of cloth. Then try to secure the best contrast which will retain all the shadows. When the short exposure, the proper distance, and the medium dosage of rays has been worked out for this result, the experience will cover a great range of radiography for diagnosis. It will be especially helpful in aiding to detect calculi of various kinds, and this is work that seems difficult to most physicians who have not worked out the "dosage."

CHAPTER XIII

RADIOGRAPHIC EXPOSING TECHNICS

Rudimentary Studies. Position of Tube in Holder. Distance of Tube from Film. Relation of Tube to Patient. Position of Patient for Radiograph. State of Tube. Preliminary Observations. Immobilization. Practice Exposures for Beginners. Exposure Time. Proper Records.

Many of the rudimentary steps of X-ray work are as strange and difficult to the novice as radiographing a gall-stone is to an expert. Most writers pass them over as too small to mention, but a new student needs to know them and we shall consider the basic steps in this chapter.

Position of Tube in Holder.—Secure the tube in the holder so that the diagonal electrode within the tube faces the object which is to be examined. Also set up the tube so that the diagonal electrode (the anode) is nearest the positive side of the battery, and the round concave electrode (the cathode) is nearest the negative side of the battery. It is obvious that the rays can be directed toward the patient or the examiner with the tube in a wide variety of positions, some of which will be far less convenient for the connecting wires than others. Therefore, while the first need is to adjust the tube so that the platinum reflector fronts toward the patient, it is wise to adapt this adjustment to the position best suited to carrying the connecting wires between the terminals of the tube and the battery. This position approaches the horizontal in the majority of cases. Having first made the general connection in the manner adapted to regular work, the final modification of adjustment is made to suit a special examination. These adjustments consist of slight turnings of the tube one way or another to conform to the best examination of the part after the proper general connections of the tube have been made.

Distance of Tube from Film and from Nearest Surface of Patient's Tissues.—Theoretically, the greater the distance between the tube and the plate the more perfect the picture will be. Practically, the working power of X-radiance diminishes so rapidly with increasing distance that very little work is attempted beyond three feet. A very thick part of the body can be radiographed at three feet with as little enlargement of the shadows as would be caused at one foot with a thin part. The needs of the case do not require the operator to put the tube at the greatest distance his apparatus will work. The chief reason for making exposures with the tube closer to the plate is the more rapid chemical action and the shorter time required.

A compromise, then, in the matter of distance, *aims at approximating normal shadows with reasonably short exposures.* Small work may be wisely done at distances of from fifteen down to ten inches between the anode and the plate, in order to secure rapidity of action. Medium work is satisfactorily done with fairly short exposures at from sixteen to twenty-four inches between the tube and plate, and, as it is well for the operator to accustom himself to a standard measured distance for all work falling within its class, it would be well to adopt *twenty inches* as the *standard* distance for medium densities and thickness.

Through the thickest parts of the body the requirements of the radiograph may differ in different cases. It is wise to get the tube not only far enough away from the plate to reduce the divergence to *a low angle*, but also to get far enough away from the nearest tissues of the patient to avoid every conceivable liability of damage, even though the risk is of microscopic size. While it is considered that twelve inches between the tube-wall and the tissues is sufficient for safety, yet some operators make thirty inches their rule with the trunk of the body. Very high-efficiency apparatus is required to make a rapid picture at such a distance. The beginner will do well to avoid both extremes.

With small and medium work references to distance mean the distance between the *anode* and the *film.* In exposing the trunk of the body, we take into account the distance between the wall of the tube and the tissues, and if this is never less than twelve inches the operator conforms to good practice with reasonable limits of exposure.

It may be said here in passing that modern radiography with efficient apparatus never demands the exposure of a patient for a period more than a third or a fourth of the time required to render the patient liable to dermatitis. In small and medium work the exposure is usually less than a twentieth of the time required to cause irritation. If the beginner keeps his tube not less than twelve inches from the tissues in any exposure that lasts more than five minutes he will have a large margin of safety.

Test for Relative Distances in Radiography.—It is the rule in radiography, as in all definition of shadows cast by any form of light, that the object must be near the plate or screen, and the point of light must be neither too far nor too near, but at a distance which is related to the width and thickness of the object shadowed and such that the rays will pass its edges with a minimum of diverging angle. The author's Divergence Chart teaches all variations of this rule in visible diagram, but to test the matter in a radiograph take a pine block four inches square, run a diagonal line from one corner to another, and drive in a row of small wire nails one-half inch apart on the marked line.

Lay the block on a plate in its paper envelopes and have the nails horizontal to the film, but rising like steps from contact with the plate to four inches distant. Then expose with the tube at ten inches, and again at twenty inches, and again at thirty inches, and develop all the plates and compare the joint actions on the size and clearness of the nails, noting:

1. The space between each nail and the film, and
2. The space between the nails and the point of light in the successive pictures.

At the distances which permit the object to be spanned by rays which make the nearest possible approach to parallel, the shadow of a given nail (or any object radiographed) will be the nearest life size and have the sharpest outlines.

Relation of Tube to Patient.—As the tube contains the anode it has become the general custom to refer to the position of the *tube*, but it is very unscientific to do so and allows too much latitude for accuracy. The important thing is the focus point. The relation which this should bear to the patient must be considered from two stand-points: distance and perpendicularity. An object of much thickness on a photographic plate will be magnified too much if the focus is too near. The shadow will be carried too obliquely if the focus directs slanting rays through it. Therefore, to obtain radiographs of diagnostic value the shadows must be as nearly life-size as possible and as free from distortion as possible. Studies of distortion in another Section make the reader familiar with its causes.

The rule of correct practice is simple. *Adjust the focus far enough away from the part to magnify it but little*, and *straight enough over the part so that the rays striking the centre of the plate will be perpendicular*. The author's Divergence Chart and Position Finder are exact guides to securing the correct relation of the focus with the patient. They are described in their special sections.

If the shadow of any part within a part is sharp and not magnified,

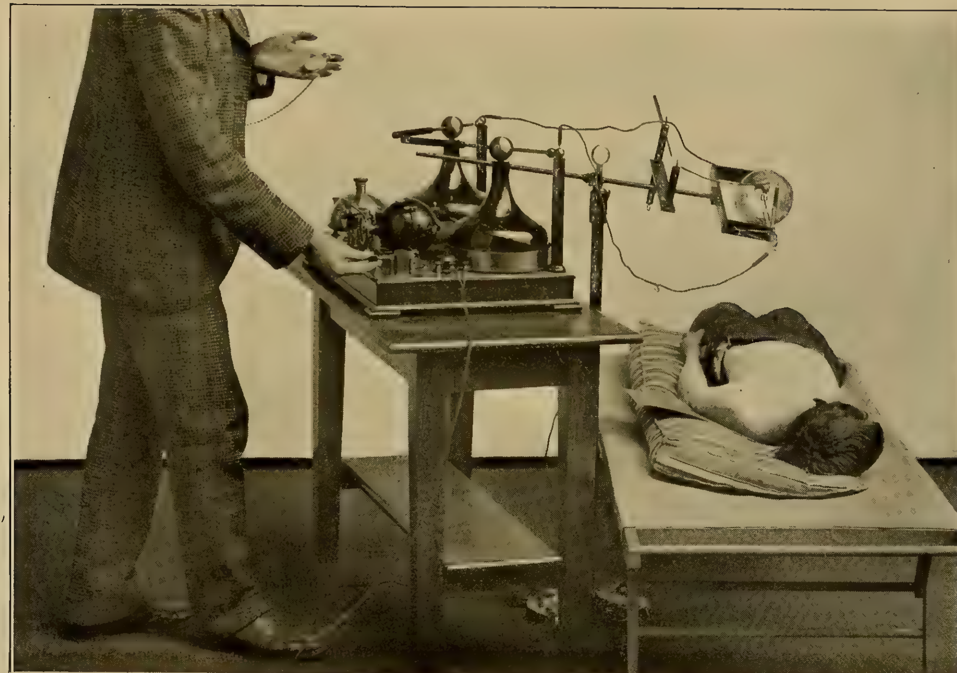


Plate 33.—Radiograph of Shoulder. Note manner of making close contact with the film by side position of patient. Operator holding watch to cut out current.

Plate 34.—A Correct Exposure of the Ankle. The tube is fixed centrally with the focus at right angles to the part. The plate-holder and foot-rest are adjustable to distance in the path of the rays, but cannot move out of axis. Slide it to twenty inches from the anode, place the foot in position, insert the film or plate, press the part against it, and make the exposure.

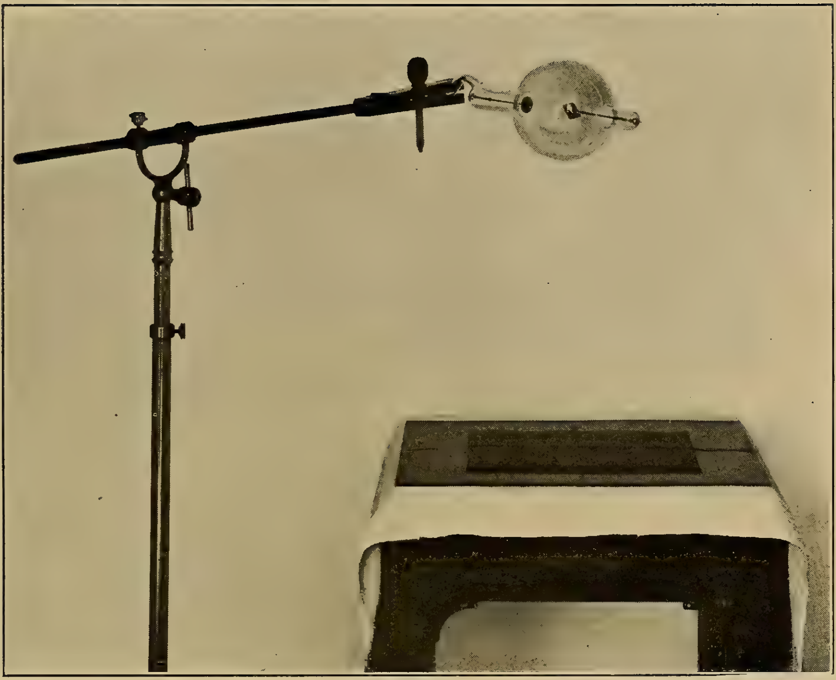


PLATE 35.—Cross-wires for marking quadrants on negative. It is often useful to so mark the negative that it will show the central point of exposure with the field divided into four right-angled parts. This Instruction Plate shows a plate in light-proof envelopes on a base which has two cross wires drawn tightly over at and intersecting in the middle. Focus the tube vertically over the point of intersection and freshly wet the cotton wrapping of the wires with any ink that will mark the skin. Then place the part on the plate and make the exposure. The marks of the wires will be imaged on the negative by the rays and printed on the skin by the ink. Thus the radiograph and part can be compared after the plate is developed and any desired measurements may be made. This device is especially employed in making stereoscopic radiographs. It is well to lay a metallic letter R on the upper corner of the right-hand quadrant to identify it for all examinations.

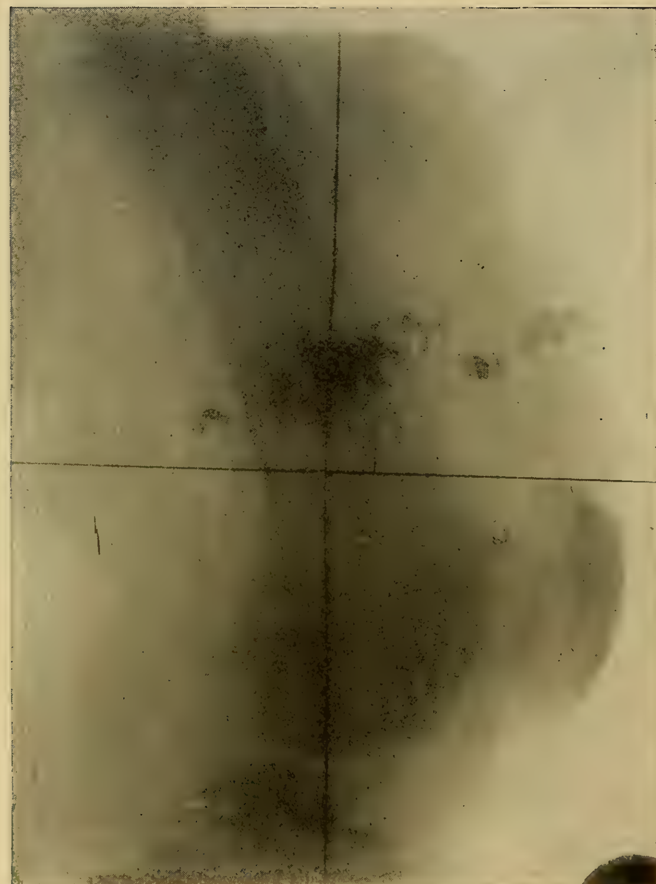


PLATE 36.—This plate shows the markings on the negative of the cross wires illustrated in the last figure which divide the picture into equal quadrants and assist in defining the examination of the negative and print. Some operators use this form of landmark for all radiographs.

it is proof that the object casting it was near the film, and per contra, if any shadow is enlarged and hazy on its borders, the tube distance in both cases being correct, it is proof that the object is at some interval from near contact with the film. These laws of definition are both well illustrated in the frontispiece, the two circles being made of the same steel wire. The contrast is more extreme than in any part of the body, because the hazy circle was a greater distance above the film and nearer the tube than tissues are.

Position of Patient for Radiograph.—Cases fall into two classes: those who can move freely and assume any desired position, and those who cannot. Hospital cases in helpless conditions or immobilized must be exposed as they lie on the bed or stretcher, and the plate and tube placed according to the necessity. Some advise that the plate should generally be above the part and the tube underneath, but this is often more trouble and no better than some other pose. If the part is reversed in the picture because of the position of the negative during exposure, simply use a mirror in inspecting it, and the normal relation will appear.

We have all seen lengthy directions, even filling several pages, stating separately how each and every part of the body should be postured for exposure, and how the tube should be placed opposite a certain anatomical location, etc. To remember them would be a task if it were necessary, but happily it is not required for correct work. We shall here teach one universal rule that applies to every part of the body, and sweeps away all the confusion of past methods.

1. Select a plate adapted to the size and shape of the part.

2. With the fluoroscope, or by other means of examination, locate the field for examination and the best direction for the rays to traverse it.

3. Mark the centre of this field on the skin of the patient.

4. Centre the plate and tube by the author's Position Finder, the one method serving for all cases and parts; or, when more convenient, use the author's Examining Frame to place the tube. The principles are the same, and both secure vertical rays within the field exposed.

5. Place the plate in the frame, or on the base of the Position Finder (whichever is used), and simply insert the patient in the fixed path of the rays so that the marked spot on the skin is on the marked centre of the cover of the plate. The accuracy of the radiograph then becomes automatic for any part so placed. This is simpler than complex directions oft repeated in print by writers who make no effort to standardize their technics. See chapters on author's "Posi-

tion Finder" and "Examining Frame" for complete description of each. For distances refer to remarks on author's Divergence Chart. These standard teachings are here put in print for the first time.

In examining any thick part of the body, as the trunk, either with a fluoroscope or by making a negative, place the front, side, or back of the part in contact with the screen or plate according as the object of examination is nearest the front, side, or back. Follow the rule that the nearer the part to the plate or screen the better will be the shadow, and if a tumor, bullet, or organ is nearest the front then examine from the front. The principle is of general application. Remember it for all uses.

State of Tube.—Before making an exposure for a radiograph, always make a last test of the tube before the plate is brought from the dark-room. Not only ascertain by this test that the selected tube will instantly light up, but determine the regulation of the current which will produce the needed efficiency of radiance. Fine work requires that *the activity, penetration, and quality of the rays should be approximately suited to the case in hand.* The requirements for a picture of normal bones (especially thin bones) may differ much from the requirements for soft parts and for thick bones. The acquired judgment of the operator will, therefore, regulate his tube according to the part to be radiographed, and the *purpose* for which the picture is taken. The advance test is also important to save ruining plates. If the tube proves refractory another can be substituted before the picture is spoiled.

Preliminary Observations.—Accompanying the test of the tube should often go hand in hand a fluoroscopic examination of the part of the body which is about to be radiographed. It will save many plates to know in advance both where to put the plate and how to place the part. Operators who have been seeking to locate a bullet and have ignored the preliminary fluoroscope have time and again exposed a plate and found no bullet. On making a second exposure with a plate in a second situation the bullet has perhaps appeared on one end of the plate; but the first picture could have shown it without delay and with a minimum of obliquity if it had first been traced with the fluoroscope and the plate put approximately under it in the line of the anode. Fractures also illustrate the same point. View a part from several directions and determine in advance the best view point for the radiograph and the proper situation for the plate. Then proceed with the exposure as taught.

While the above point is briefly stated yet its importance will appear to the careful operator throughout nearly the entire scope of his work. Find out in advance where the plate should go and from what direction the rays should pass through the tissues to secure the best result. It will save many laments.

Immobilization.—With less careful operators clear definition and sharp outlines are often blurred by slight movements of the patient during the exposure, or vibration of the tube in a tube-holder that lacks rigidity. All are familiar with the necessity of having the camera and the patient absolutely still during the making of a portrait, and the same rule applies to the radiograph. Different people vary to an extraordinary extent in their idea of keeping still, and some operators use a tube-holder so unsteady that it will be affected by walking across the floor. A rapidly run Static machine will also often conduct vibrations from the floor to the tube unless precautions are taken.

First make the patient comfortable and secure in the necessary position. Next instruct him to close his eyes just before the tube is started into action. Impress upon his mind that he must keep absolutely still and pay no attention to what is said or done around him, or he will spoil the picture. Ask him no questions and allow no one to touch or speak to him during the exposure when the posture is volitional. When parts are tightly strapped to a frame or table this precaution is not so necessary.

Removal of Clothing.—The entire removal of clothing from an exposed part is often advisable for some other reason than the effect of clothes on the penetration of the rays, which may be nil. As a protection against cold contact with a plate or chill in a cold room the retention of ordinary underwear is often permitted, but every layer of thickness in addition to the wrappers of the plate increases the space between the film and the tissues and lends some magnification to the picture. This is less when the tube is at a greater distance. In no case should the patient have any buttons, steels, pins, or anything that will cast a foreign shadow in the field. Even a fold of a thick garment may do this.

In surgical cases cotton bandages and wood splints offer little resistance to the rays and examinations are made through them, but if they prevent proper contact or relation of the part with the film allowance for the effect on the shadows must be made. Plaster and iodoform will cast shadows depending on their density, and if allowed for they need not be a source of error, though fine detail will be lost through them sometimes. Rubber tubes and even rubber or paste plasters may cast a slight shadow, which must be discriminated from disease. In fine and difficult examinations for primary diagnosis it is a good rule to clear the field from possible interference, but in merely watching progress all dressings can be allowed for.

Practice Exposures for Beginners.—Two persons who will measure the same diameter in the cross-sections through which a radiograph is taken will not require exactly the same exposure, with the same intensity of radiance, for the density of bone and soft parts differs with advancing age, and with the conditions of disease or health. The photographer taking landscapes or portraits, indoors or out, will observe the quality of light and vary his exposure accordingly. Exactly the same judgment must be used in X-ray exposures. To learn to readily approximate what allowance must be made, make tests with two subjects presenting some contrast in condition and age. Take four 10 × 12 plates. Fix the tube with the anode twenty inches above the centre of the plate. On one plate then expose an elbow from each subject, placed side by side in similar positions on equal sides of the centre. On a second plate expose two ankle-joints. On a third plate expose two knees. On the fourth plate expose the foot of an adult over forty years of age, and the foot of a child eight or ten years old.

Make each exposure with the tube working at the same efficiency, and give each plate the time you think best. Keep a record of it. Neither specific time nor distortion is important in these trial tests.

Develop the plates and compare the results. From the study of two or three series of such tests the beginner will derive sufficient judgment to make allowance for age and density in different subjects.

Exposure-Time.—All that can be advised about exposure-time by one operator using one apparatus can be disputed by another expert using another apparatus; and the critic fortified by theory and intrenched in confident ignorance can lay down still different rules for the beginner. With the same apparatus the expert can produce two negatives of good appearance, one with twenty seconds exposure and the other with twenty minutes. But just as we have advanced from the minutes of Daguerre and of ambrotypes to the quick photography of to-day so we will learn to regard X-ray exposures of minutes as the crude necessity of pioneer work. At present few men seem to object to two minutes as an ordinary exposure, but there are advantages in two seconds which will make two minutes obsolete as soon as plate-makers can mix an emulsion sufficiently rapid to X-rays. While many are not yet awake to the need of reducing these exposures to the plane of modern portrait photography, yet others appreciate the gain and are striving to bring it about through films of new composition unaffected by daylight.

PLATE 37.—Inspection of lungs posteriorly. Sit the patient on a chair higher than the one to be occupied by yourself. Level the tube as shown in this instruction plate. Have the patient raise both arms to remove the scapulæ from shading the pulmonary tissues, make close contact with the screen (or fluoroscope) in the axis of the rays at the standard distance from the tube, as here shown. The next step is to sit down comfortably in a chair that will bring the eyes easily on a level with the field to be examined, throw a black cloth over the operator's head and shoulders of the patient to enclose the open screen in darkness, and proceed with the examination as taught in the text. The operator has a choice of using a regular fluoroscope, or the screen taken from the box as here illustrated, or a larger mounted screen fixed on a standard. The latter is shown in plate illustrating the Skiameter.

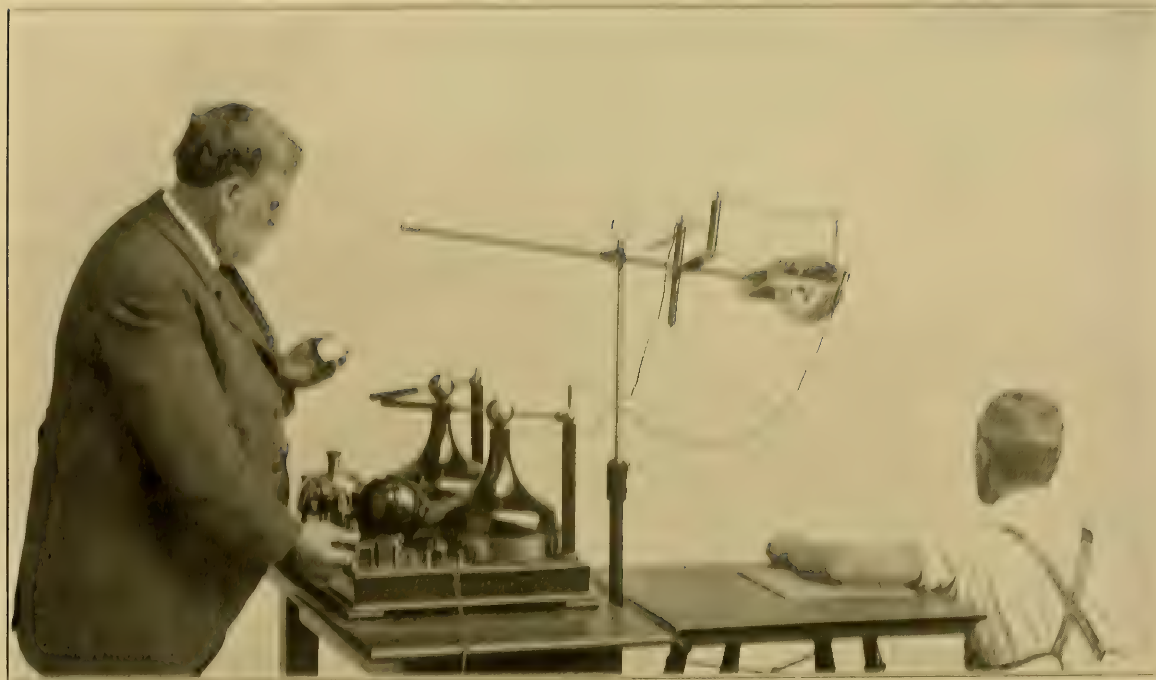


Plate 38. Showing ordinary manner of exposing elbow for radiograph. Compare it with technic of frontispiece and observe the greater accuracy of the latter. This plate also shows on the standard a simple shunt resistance regulator for adjusting the dosage of the tube. The operator is seen holding watch to time a five second exposure with this coil.

Plate 59.—A Study in Penetration through different layers of plastic splints of different densities. Every X-ray operator should make test negatives for the instruction of experience. (Rebman, Ltd.)

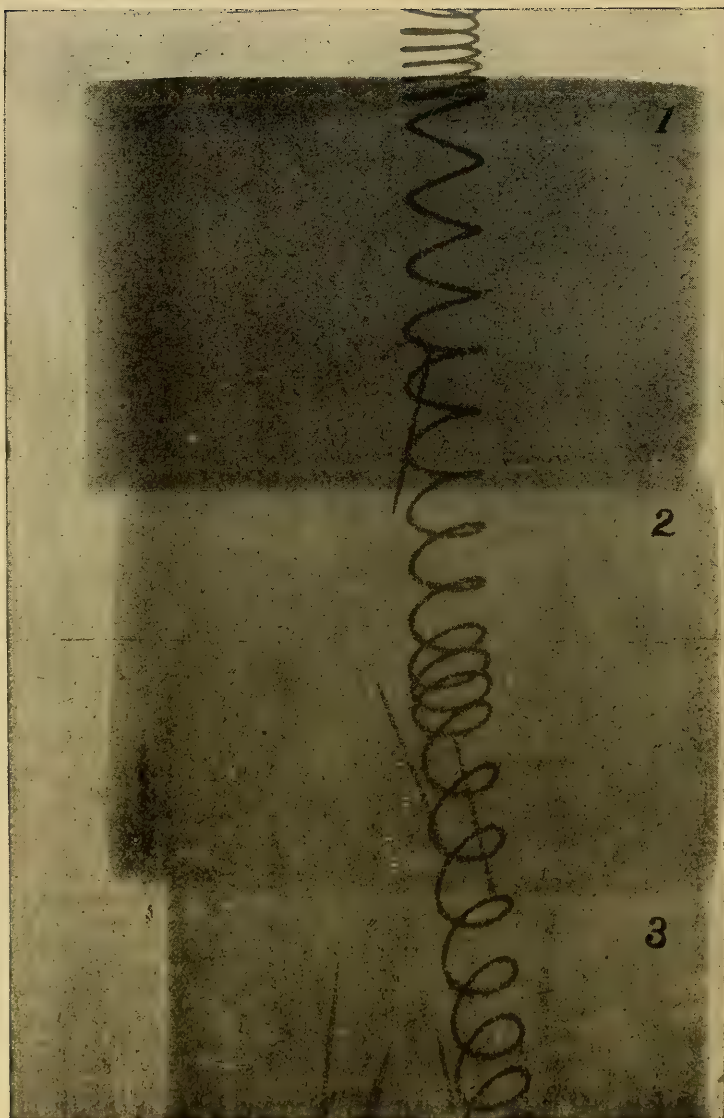


PLATE 40.—The beginner should make a series of negatives showing effects of different bandages, wires, pins, etc., entering into surgical radiographs, so as to become familiar with penetration and shadows. (Rebman, Ltd.)]

Recently a writer of international reputation expressed the general view of experts as follows:

"It is very often overlooked that, apart from the benefits accruing to the patient and the operator, a short exposure also greatly minimizes some of the technical difficulties which attend exposure, particularly of the deeper tissues. All are aware that in addition to the direct emission of X-rays from the anode there is a plentiful generation of secondary or diffused X-rays from all particles in the body through which the rays pass, and also in the surrounding air. This radiation is in itself feeble, but may and does affect the photographic plate if it lasts a considerable time. Reducing this time is, therefore, equivalent to reducing the disturbing effect of these rays upon the plate, an effect with which you are all familiar; namely, the foggy appearance of long-exposed plates. Moreover, I believe there are certain electro-static phenomena which also produce an effect upon the plate when exposing the latter for a prolonged period to a highly charged tube. Thus, generally speaking, a short exposure is likely to give more contrast in the negative, quite apart from considerations of economy, which should direct our efforts toward reducing the time of exposure by every means."

The factors which control the time required to produce a picture are (1) the activity of the radiance; (2) the rapidity of the emulsion; (3) the means employed to increase actinic action; (4) the thickness and density of the part, and (5) the personal equation behind the technique. These factors are directly influenced by the efficiency of the electrical instalment and the tube. While equal work cannot be done with widely different capacities of apparatus, yet the mere factor of *time* can be shortened with weak rays by getting them close to the film. This, however, is not good radiography.

A table of average minutes for each part of the body may be printed in a dozen different ways without benefit to the novice who is alone in his office, with but *his own apparatus to work with.* By extraordinary methods of detail experts can compile a similar time-table, in which minutes are reduced to seconds; and many specimens of "instantaneous" pictures have been made. Ordinary practical, surgical, *diagnostic* radiography is quite another thing. The object is not to make the shortest possible exposure, but to make the exposure which will produce *the character and degree of image required for diagnosis.*

What we shall aim to do here is to substitute for the prevalent rule of printing a list of exposure-times a practical method of instructing each operator how to *find out the capacity of his own apparatus* with scientific precision and without ruining plates by guesswork exposures.

Make the following series of tests on each part of the body of a normal adult of medium proportions. By each part of the body we here mean hand, elbow, shoulder, thorax, foot, knee, hip, and skull. First test the standard distance of twenty inches between the anode and the plate. Use for these tests a small plate, as the purpose is simply to ascertain the relation between the defining power of definitely ascertained degrees of X-radiance and your watch. The size of the picture is not important, and small plates cost very little.

Conveniently out of line with the plate, but in the path of the rays, adjust the author's X-ray penetration gauge at the distance of twenty inches from the anode. Use the set of thin shutters, which permit the finest differentiation of light.

Start the tube into action, and when it attains about the degree of efficiency which represents what you can usually rely upon with your apparatus, measure and record the penetration. Then, make one exposure of the selected part with an accurate record of the time. Let the first exposure be a little less than what you think would be necessary. Remove the plate and immediately expose a second plate with the same degree of radiance, and for one-third longer time. Make a third exposure under the same conditions, doubling the time of the first exposure. If possible to increase the brightness of the tube to a marked extent do so, and, having measured the radiance, make a final exposure of the same duration as the one preceding it.

With these records, and each plate marked for identification, develop them and compare the results. One plate will be under-exposed, another may be exposed unnecessarily long. Having determined which plate is the most satisfactory radiograph, the record of its time and other details of technique afford a starting-point for the next test. Take a somewhat thicker part, and estimate the allowance of time required for the additional density. Base the estimate upon the results of your *best* picture in the first test. Adjust the tube to exactly the same degree of efficiency and expose a new series of three or four plates. Having developed them, a comparison of the results will be *far more instructive as to the capacity of your own apparatus* than will a large amount of reading about results made in Germany.

Following this series of tests the operator can in the course of time compile his own records, which will be of the greatest value to him in his individual work. Make them gradually cover records of the photographic activity of an ascertained degree of penetration at a known distance from the tube through the different densities of the body, with relation to subjects of different ages and of different bony and muscular development. On the results of these tests future work may be based with scientific precision with respect to your own apparatus, whether it is any type or size of coil, or any type and size of Static machine, whether your tubes are high or low, new or old, plain or complicated. *Exposures will thus be taken out of the uncertain realm of guess-work, and the watch, the gauge, and the record will save many plates* of much greater cost and importance in actual future work after these tests have laid the foundation of *accuracy.*

Note that neither the brightness of the apple-green phosphorescence of the tube-wall during an exposure, nor the appearances observed through a fluoroscope by the unaided eye, are a scientific basis for precision in timing exposures with different tubes, or the same tubes on different days. But the author's standard *gauge* permits a measure of the richness and penetration of the X-ray discharge which is mathematically correct. Full directions are given in the Section describing this instrument.

Timing Exposures.—For this purpose a sweep-second, fly-back timer will be found convenient. They are made to time from 0 to 30 minutes. The sweep-second hand marks seconds in fifths. A small hand marks the minutes. When ready for the exposure pressure upon the crown-push starts the watch going. At the end of the exposure a similar pressure stops the hands, and they remain stopped. The record can be noted at the operator's convenience, and when ready for another exposure a pressure on the crown sends the hands back to zero and a new start is made as before. When much work is done, especially in a darkened room, the ordinary watch-dial is unsuitable, and a timer of this kind is certainly a useful if not an indispensable adjunct.

Making Records of Exposures.—In reporting coil-work the record of the current exciting the primary should be stated always; and with the increasing variety of interrupters it is as necessary to state the kind of interrupter used, and, if possible, the approximate rate of frequency, as it is to mention the size of the secondary coil.

But when the author's practical X-ray gauge becomes the universal standard measure of X-radiance at any distance from the tube the two essential factors of record will simply be (1) whether the rays were X_1, or X_3, or X_5, or X_{10} in power, and (2) whether this degree of power was active at ten, fifteen, twenty, or more inches from the focus.

The record of the exponent power of X, and the distance of the anode from the surface will also greatly advance the standard of dosage in X-ray therapy. The habit of making complete records should be cultivated, and the operator should obtain the few instruments needed for accurate records of genuine scientific value.

CHAPTER XIV

STUDIES IN PHOTOGRAPHIC TECHNICS

TREATMENT OF X-RAY PLATES AFTER EXPOSURE. DEVELOPING PROCESSES. ELEMENTARY PRACTICE FOR BEGINNERS.

No part of radiography seems so formidable to the novice as the part which takes him into the unfamiliar domain of the photographer's dark-room and asks him to develop his own plates. The already expert amateur has no obstacle of this kind, and after a week of practice the novice will lose timidity and find interest and recompense in this important and not too difficult branch of technics. Occasionally the demands of plates upon the operator's own time may be tedious, but when much work is done an assistant will be a part of the equipment and will at once remove all minor details from his superior. The question of sending out plates to a professional photographer for development will be discussed later.

The beginner without previous photographic experience will first want to know what plates to use, how to handle them, what developer to prefer, and how to use it; how to distinguish and correct defects, and other details. He will also want to know how to prepare a simple "dark-room," and the most important of these points this chapter will aim to teach. For the more obvious mechanical details of photography it is better to have a local photographer take you into his work-room and let you see his supplies and watch him manipulate development. It would take many pages of reading to get the same instruction, and we reserve our space for other features. Any large photographic dealer can furnish the supplies needed for the dark-room.

The Home-Made Dark-Room.—Do not transform a small closet into a working dark-room. The damage to your health and comfort in X-ray work will be almost wholly the fault of a close, stuffy, unventilated, too small exposing-room and dark-room. Allow yourself a room at least ten by fifteen feet in size, and obtain sufficient ventilation to keep the air healthy. The prime considerations of equipment are few. A proper adjustable ruby light, a working table, shelves, trays, and running water are needed besides the chemicals.

The important need is the exclusion of *actinic* light. Rays must not stray in through cracks and key-holes.

Do not understand the word "dark" to signify that the operator must work in almost total darkness. The term is relative rather than absolute. Quite enough "light" can pervade the room for all practical purposes, but the essential requirement is that it shall be *non-actinic* light instead of ordinary illumination. The model dark-room is not really an *erebus*.

A Shifting Ruby Light.—Not the least of the many advantages of an electric-light is the fact that it can be tilted and turned upside-down without spilling oil or reversing a flame. Therefore, a commercial electric circuit in the office can be most profitably utilized in the dark-room.

Fit a plate of proper ruby glass in the top of a wooden box about a foot square, painted black. In the box conceal the low-candle-power electric lamp, using a long and free flexible-cord attachment to the source of current. Run a trolley over the developing table at the height of the head, and from it depend the lamp-box on a rod with a universal hinge. At one corner of the box nail a small handle, and prove by test the light-proof quality of all the joints. Use one of the new pattern of lamps which can be turned down through three or four steps from full incandescence to a mere glow.

In use, with more than one developing-pan on the table at the same time, this box can be seized by its handle and turned light down over the first pan, and next shifted to the second or third, or can be turned partly or wholly away from any or all of the pans. Its red light can be shed in front for the benefit of the operator while only a dark side of the box is toward the plates. It can be run beyond the field of the plates altogether, or can be reversed or turned upward if desired. In fact it is needless to attempt to narrate the many variations of adjustment supplied by this useful box and lamp. The operator who installs it will at once see its great convenience, and will require no further suggestions beyond the hint of the idea.

A Home-Made Safe for X-Ray Plates.—From ordinary five-eighth inch pine-boards have a carpenter construct a box with a close-fitting hinged door. Make it about eighteen inches wide and high and fifteen inches deep, inside measurements. With thin partitions divide the space as a safe is divided for blank-books, the plates to stand on end. The largest compartment will then hold a dozen 14 × 17 plates, and others will take decreasing sizes down to the smallest used. Lay no plates flat.

Next get from a hardware store two pieces of sheet-lead one-sixteenth of an inch thick. Fit one piece completely over the outside of the box except the front door and tack it fast. Then tack the second layer over the first. Then lead-plate the door. In use keep this safe in the dark-room with its back toward the room containing the X-ray apparatus, and place the latter so that all tubes will project their rays away from the contents of the box. It requires but a little management to so arrange a coil or Static machine that tubes will point in a direction opposite from the dark-room, and this single precaution is a great preservative of plates. The lead casing of the box is sufficiently thick to protect all unexposed plates at distances of more than ten feet from tubes, yet is not too heavy to be moved with ease.

With ordinary tubes placed with their dark hemisphere toward the box the field of safety is much less than ten feet, but it is better to have sensitive films beyond even the suspicion of stray light. Beginners will keep in mind the fact that neither wood, plaster partitions, nor many feet of distance, will protect plates from powerful rays if they are in the path of the rays and are not behind opaque metal as we have described. A plate even partly fogged by proximity to penetrating rays is lost. It is economy to also keep plates cool and dark till used. The *fresher* the film the better the result.

Choice of Plates for X-Ray Work.—Radiographs may be made on photographic papers, films, or glass plates. Every known emulsion has been tried. Good pictures have been made with any and every kind of plate, film, and emulsion. Of the nine leading manufacturers of photographic dry plates in the United States, four so far offer special "X-ray plates," which are more thickly coated than regular films. A great difference of opinion exists among experts as to choice of plates. It is assumed that an expert will prefer the plate to which he is most accustomed, and that with it he will get better results than with a strange plate which may be superior. But an expert ought soon to do the best work with the best plate.

It may be estimated that about 3,000,000 plates were used for radiographs in 1901. As much larger sizes are employed than Kodak amateurs use, they cost much more than would 10,000,000 plates for popular cameras. The incentive to manufacturers would seem quite great, but it is even now a trouble to procure "X-ray plates," and involves delay and often a special order. Therefore, probably seventy-five per cent. of the work is done on ordinary plates. This is not fair to the surgeon, nor does it assist *advance*. Manufacturers should solve the problem of producing a plate with an emulsion of the right thickness and of almost instantaneous rapidity. It should also be insensitive to the daylight of an ordinary office, so that it can be exposed and developed with neither wrapper nor dark-room.

Tests of thickness of coating have been made. Unsurpassed pictures have been made with a single coating, but it is held that a double coating will afford greater depth and contrasts in average pictures. Experimenters claim that *three* coatings add perceptibly to depth and contrast. Four coatings have been tested, but probably three are sufficient. It is asserted that the maximum result with a triple-coated film shows an astonishing difference over a single-emulsion plate, and that the printed detail is exquisite. Those who have employed multiple-coated plates recommend them as far superior to others.

An attempt to increase the depth and contrast of shadows has also led to the manufacture of films and plates *coated on both sides*, so that the shadow underneath will reinforce the shadows of the upper layer. Some of the best work in the world is done on *double-sided films*. A similar result is aimed at by superimposing two, three, or four ordinary glass plates or films for a single radiograph.

Upon the subject of photographic plates for X-ray work a prominent expert has remarked:

"It was in one sense unfortunate that X-ray light affects bromide of silver in the same way that sunlight does, though to a less extent. Makers have introduced special X-ray plates by using a thicker emulsion or by coating the plate on both sides, which comes to the same thing, but it is the same bromide of silver in gelatine that is employed, and this is so enormously transparent to X-rays that probably not five per cent. are retained by the emulsion, the remainder passing through the plate and being lost. What we want is an emulsion that shall be at once sensitive and opaque, and so retain the X-rays and make them do chemical work. What we want is a plate that shall be as good for X-ray light as other plates are for other lights, and *the ideal X-ray plate will be one that is insensitive to sunlight and which can be exposed without a wrapper and developed without a dark-room.*"

It is generally suggested that the beginner should select any good plate, and then stick to it, as "familiarity will enable him to handle it to the best advantage." While correct in theory, the logic of this idea would retard progress. It is inevitable that improvement will take place during the next few years. *We are approaching the era of instantaneous radiography. All who use plates should be alert to test advances as they are made, and thus promote progress.*

Buy only a half dozen plates of the larger sizes at a time and get them fresh when needed. Do not keep in stock a greater number of plates than you expect to use in about two months. Any plates remaining on hand after three or four months may be good if kept in a cool place and protected, but do not risk an important picture with an old plate. Better throw them away and get fresh ones.

Makers now supply orange and black envelopes to serve instead of plate-holders for X-ray work. When first introduced, in 1896, orders were filled with the plates inserted in the wrappers and sealed, but this is no longer done. In time the inclosed plates deteriorate through unavoidable chemical action of the paper. The envelopes are furnished separately and plates inserted by the operator as needed. Do not keep stock plates long in exposing envelopes.

The great defect in present plates is that X-rays pass so readily through gelatine emulsions that the brief period of photo-chemical action on the silver makes them "slow." The problem is to mix the silver salts or other possible agent in an emulsion that shall be sufficiently opaque to X-rays to hold them in longer action. Makers have indeed tried countless experiments, but harder problems had to be solved before camera photography took its present place, and we may expect the final adaptation of films to the kind of chemical action possessed by the light from a Crookes tube. The true X-ray plate may delay its coming, but it will get here in the course of time and find a hearty welcome.

In England Cristoid films are spoken of as follows by a surgical writer:

"This is a departure from the regulation plate and film, inasmuch as it consists of two films which are so thick that when superimposed they require no support. Therefore, neither celluloid, paper, or other strengthening material being used, they are absolutely free from any texture or grain. They are also non-inflammable and practically unbreakable. They are supplied in boxes of one dozen, each film placed in two light-proof envelopes. In sensitiveness they are as quick as the quickest plates made. Excess of exposure only produces excess density, which may be readily reduced for printing purposes by means of a weak solution of ferricyanide of potassium. In developing, the directions of the makers should be explicitly followed. After the preliminary bath, the negative cannot be scratched and may be handled with as much impunity as a piece of ordinary wet linen. Several may be developed at the same time if each film is thoroughly wet before putting another in the dish. A well-exposed negative may be developed in about six minutes. Frilling is an absolute impossibility. The films may be kept and developed months after exposure. Tropical dry heat does not affect them in the least. Any one having to carry a number of glass plates will appreciate the lightness and unbreakableness of these films."

For these "Cristoid films" Sandell (the maker) claims the following advantages: "Their latitude (of exposure-time) is so enormous that almost any degree of over-exposure may occur without risk to the ultimate result, thus yielding, under these circumstances, an infinitely better differentiation between foreign bodies, lesions, or disease, and the normal surroundings than any other plate or film." It has been stated by men using these films that two pictures of the same part, one given two and the other twenty minutes' exposure, produced equally perfect detail and quality of finished picture.

In Germany the finest radiographs are made on X-ray films of the Schleussner Company, Frankfort-on-the-Main, which, however, are very expensive. A few specialists have imported these films for use in this country, and have deemed them worth the cost and trouble of getting them.

American makers are now producing a film on celluloid which they recommend highly, but American surgeons could no doubt *hasten the coming of the ideal X-ray film or plate if they would unite to demand it of manufacturers instead of following the popular advice to use any plate and "stick to it."*

Bromide Paper and Multiple Positives.—As early as March, 1896, the desirability of getting a positive, or several positives, without being compelled to make a negative and wait for it to dry before a print could be obtained, suggested the use of superimposed layers of bromide paper. Some use the method occasionally, some make frequent use of it and praise its value, while others condemn it.

Developing Solutions.—When the chemical action of light has written the exposed image upon the emulsion of a photographic plate it is still an invisible and transitory writing, and the image must be "developed" to be made visible, and be "fixed" to secure permanency. Therefore, developing solutions and fixing solutions are the photographic "transformers" required to make light-writing useful.

Of the many varieties of chemicals employed in the complex processes of all branches of photography, both acid and alkaline, the radiographer need consider less than half a dozen, and these are all alkaline. It is generally agreed by veterans that no other developing agent so readily imparts all desirable qualities to a negative, and affords such latitude in adapting it to detail and contrast, as pyrogallic acid, familiarly called "pyro." While "pyro" is the best all-round developer, it oxidizes easily and stains the fingers, clothes, and whatever it comes in contact with. Rubber gloves, a protecting outer garment, and certain precautions minimize the drawbacks of pyro and bleachers will wash it off.

Metol and hydrochinon have been for the last few years the popular rivals of pyro. They do not stain the fingers or the film. Metol is said to excel in giving detail and softness, while hydrochinon gives strong contrasts and hardness. Many, therefore, combine the two in a working formula, and vary the proportions of each as required. For, while the quality and quantity of actinic action upon the emulsion dominates the photographic result, yet the *expression* of the result is greatly influenced by manipulative skill in the developing process. With every box of plates sold there is a formula for solutions advised by the maker for that particular plate. When the operator becomes accustomed to managing one solution he is generally advised to make no change till he is sure the change is an actual improvement.

Each developer consists when complete of three parts, a reducer, an accelerator, and a restrainer. The first is to reduce the silver salts and make the image visible. Pyro, metol, and hydrochinon are not only reducers, but density givers, and practically these three agents are all of their class that need to be considered by the beginner in X-ray work. They are the first choice among a legion. But as the intensity of reduction of the oxidized haloid silver salts varies according to the exposure, we need two means of regulating the action; one to hurry it when too slow, and the other to gently restrain it when too fast.

The popular accelerators are carbonate of soda and potassium, which act by "opening the pores of the emulsion" to let the reducing agent into the gelatine so that it can more quickly work upon the silver salts.

The popular restrainer is bromide of potassium, which combines with the silver bromide of the emulsion when the two are mixed, forming a double salt which reduces more slowly than the silver haloid alone.

Do not combine these three agents in a single stock solution. No two exposures being exactly alike, the modification and control of the action of the solution to suit the negative in the tray requires that each ingredient must be proportioned to the needs of the case. Therefore, keep the three solutions in three separate stock bottles and measure out each when needed to be added to the working solution in the tray.

Another ingredient added to the main developing solution is a "preservative," and the one used commonly is sulphite of soda. In mixing developers from printed formula always combine the ingredients in the order mentioned and adhere closely to the special instructions. It is needless to repeat here any of the numberless formula, for each reader will select his own, but instead of duplicating routines we will present the following communication recently received from Dr. W. L. Kenney, and will allow students to test the merit of his claims themselves.

"The formula given below simplifies development all through so that only the specialist need concern himself about varying the formula for various kinds of work. In X-ray development we desire to so alter the ratio of development as to show in the plate great differences of contrast for slight variations in the density of the anatomic structures. This is accomplished by a very concentrated developer giving dense high-lights, but preventing shadows from participating by enormous proportions of potassium bromide. I believe that the potassium bromide also acts as a reducer, at any rate preventing fog. The ratio of development is certainly altered. The developer is the ideal of compounding, whatever tubes or exposures are used.

"This formula has greatest effect on isochromatic plates, or special X-ray plates which have heavy emulsion with anilin dyes incorporated, thereby rendering plate isochromatic, but also peculiarly sensitive to X-ray and to the restraining power of bromide.

"Hydrochinon	29	grs.
Potassium Bromide	9	"
Sodium Sulphite (crys.)	98	"
Pot. Carbonate (crys.)	187	"
Water q.s. to four ounces.		

(Or, best, because most accurate)—

"Hydrochinon	29	grs.
Sod. Sulph., sp. gr. 1060	1½	oz.
Pot. Carb., sp. gr. 1060	2½	"
Ten per cent. Bromide solution	1½	drachm.

"(The dry bromide can be dissolved in the potash solution so that two and one-half ounces contains nine grains of bromide; the hydrochinon can be kept dissolved in sod. sulph. so that one and one-half ounces contains twenty-nine grains. The whole mixture can be kept united in a bottle that is *entirely* full and corked. It will then keep from two to four weeks.)

"In developing, have temperature of fluids and pans about seventy degrees, and *develop until it is barely possible to see through the bones.* Fix in ordinary fixing bath.

"So developed the negative is superior to any print. Prints are apt to lose finer shadings unless developed (or toned) on principles similar to above. Viewing by transmitted light gives a better effect also. Plates should be developed until you *can hardly see through bones in red light.* They fix out until flesh of leg is barely translucent in negative while bones appear white. A viewing box like a fluoroscope box, or any similar device, is very much better for examination of negative."

The Developing Process.—Experts acquire individual methods. The *beginner* may be instructed as follows: After the exposure of a plate it need not be immediately developed unless it is required at once. The practitioner will naturally in all non-emergency cases put his exposed plates in the lead-closet without opening them until evening, or other spare time permits. The convenient opportunity will ordinarily be obtained within twenty-four or forty-eight hours. Very much delay may possibly injure the plate, but a little delay will not. Some state that if protected properly an exposed plate will keep indefinitely without harm.

When ready to develop go into the dark-room and get out a developing tray, the solutions, gloves, and all necessary things. Light the ruby lamp, turn it very low, rinse the tray, and pour a sufficient quantity of developer solution into the developing tray which contains a "plate-lifter." Then darken the room, open the lead-closet, get out the plate, remove it from the envelopes or holder, and get ready to "wet" it.

A new solution does not readily "wet" a dry plate, but after it has been used once it does so more easily. A very large plate is more difficult to cover evenly and quickly with the solution than a small plate. With the ruby light very low and removed about three feet away, poise the plate flat in one hand with the glass down and the film up. With the other hand, tilt one side of the tray up so that the solution is deep at the side over which you poise the free edge of the plate. Now, carefully lower the plate till it almost touches the solution, drop it quickly and evenly to the bottom of the tray, and at the same instant tilt down the tray so that the solution will flow all over the film as rapidly and smoothly as possible.* Bring up the ruby light and watch for any air-bubble or spot which remains dry, and instantly tilt the solution over it. Then put the light three feet away. With one hand gently rock the plate continuously, so that the developer is kept in motion over all parts of the plate. Bring up the ruby light for better observation after a minute or so has passed, but do not bring it too near nor turn it too high, and do not let too thin a body of solution cover any part of the plate. Keep it rocking.

Watch the plate for the first appearance of alterations and *devel-*

* Or, per contra, some photographers prefer the opposite means of getting the solution over the film. Instead of putting the plate into the solution they pour the solution over the plate. Proceed as follows: Pour out into a graduate enough developer for the plate. Lay the plate film side up on the bottom of the dry tray. Hold the tray on a slant and from the highest end quickly pour the developer out of the graduate over the film. Rock the tray at once so as to spread the solution and wet the entire film. Then proceed as taught. By this method a plate can be treated with less developer than by the other plan.

opment of the picture. This may begin in less than thirty seconds, or may take much longer, according to the nature of the exposure and the activity of the solution. Note when the borders of the plate grow darker, and the first indications of the image appear. To acquire experience with your first plates then lift the plate by its edges from the tray, and hold it up in front of the ruby light. Turn both sides of it toward the light to study the back and front with *transmitted light* during the first stage of development. For this purpose pass it quickly up close to the light, but get it back again into the tray as soon as possible to avoid fogging it. After some experience the operator will not need to do this until nearer the end of the process, but at first it contains important instruction.

If the dark area spreads *rapidly* and the denser shadows appear very quickly, the development is going on too fast, and before finer and deeper shadows could be brought out some of the plate would be *over*-developed. If this is the case, lift the plate just out of the tray, quickly pour in a few drops of the *restrainer*, rock the tray to mix the solution, and replace the plate. Then proceed as before.

If the shadows come too slowly for the quality of exposure, lift the plate, add *accelerator*, rock, and mix, and return the plate.

Continue rocking the tray and watching the plate, with a view to regulating the proper strength of the developer to suit the requirements of the exposure. The time required for a normal development will be less in summer than in winter, and is also affected by the part of the body exposed. Continue the development until the film side is entirely dark, and again examine it by transmitted light. Hold it about ten inches in front of the ruby lamp, with the light turned up to the limit of safety. If it still transmits light, return it to the tray and continue to rock the solution. When still blacker, examine it again and if you can see no picture at all, but find the plate practically opaque in front of the ruby light, consider the development finished.

A normally exposed ordinary plate may develop properly in five, seven, ten, or fifteen minutes, according to the manipulation of the solutions. If the plate is *over-exposed* it will turn dark as quickly in a weak developer as a properly timed plate would in a stronger developer. If the plate is *under-exposed*, a normal solution will darken it very slowly. If the rays have acted so little on the plate that the developer has almost nothing to work on, the image may not appear even after fifteen minutes in the tray. If this is the case it indicates that the developer must be proportionately strengthened, and if the final result is too thin and weak the plate may be thrown away and a new exposure made.

If the beginner develops a hand on his first plate, and a pelvis on the second, he will be greatly instructed in the different rendering of the image as he observes it during the development. The plain outlines of the hand will delight the beginner, while the obscurity of the pelvis from first to last may discourage him into thinking that the plate is a failure.

The art of developing is not learned in a day, but if all plates were so exposed as to be chemically prepared for *normal* development there would be no difficulty about it. *Demands upon skill are made by variations in the degree of chemical action, and by peculiarities of both photographic and surgical conditions.* "Practice makes perfect," however, and in a reasonably short space of time the novice can do about all that his needs require.

One of the most difficult things for the beginner to determine is how far to carry the development of a given negative. The extent to which negatives lose *density* in the *fixing bath* varies with the length of exposure, with the density of the part photographed, with the age of the subject and particular part of the body exposed. Experience cultivates the operator better than descriptions. Ordinarily, thin parts of the body do not require as dense development as the thicker parts. When examined by transmitted light, the hand or foot need not be carried to the point of invisibility, while with the thicker parts development should not stop *until the negative is black and without a trace of detail.* Developed to this extent the image will usually fix out to the required strength and show the desired result. When softness of contrast between dense and less opaque tissues is desired, the developer should be weakened considerably and the process slowed. When near the end of development watch for commencing *fog*. Stop before the fog increases.

The development of films with *two sensitive sides* will require a pan much larger than an ordinary plate of the same size. A five by seven film should be developed in a seven by ten inch pan, and at least fifty per cent. more solution should be used than would be needed for a plate. Not only watch and rock the tray as usual, but reverse the films frequently to secure equal action upon both sides and to avoid the adherence of air bubbles. Slightly bend one corner of the film upward and another corner downward, and they can be handled in the developer without trouble. Or, a clip can be used.

In the fixing bath reverse double-sided films frequently for the same reason that they are reversed in the developer. The same principle applies to the use of glass plates which are coated on both sides. In drying double-coated films suspend them by clips in the manner usually adopted in drying paper prints.

Developing Practice for Beginners.—Take two small plates, 5 × 7, wrap in the usual light-proof envelopes, and place them side by side under a tube focused at twenty inches from the line between them. With the right and left hand of any person separately on these plates, make a normal exposure. Then take the plates to the dark-room. In a single tray develop both plates at the same time, with the same solutions, in exactly the same manner. When one plate has become moderately black on the back when held between the eye and the ruby light, take it from the developer, rinse it well in running water, and put it in the fixing-tank. Develop the second plate still longer until it becomes considerably blacker by transmitted light or entirely opaque. Then rinse and fix. Remember carefully the appearance of these two plates at the time development was arrested. When fixed and dried *compare the results.* Have a *print* made of each, and compare the prints. Note the superiority of the last plate over the first.

By making a few practice studies of this kind, the student will instruct himself to know what degree of development yields the best final result. The instruction thus gained has no relation to the number of minutes the plate may be in the solution, for the factor of time will vary with the *quality of the exposure.* The beginner will be more likely to *under*-develop than to *over*-develop, but by carrying these tests through a considerable range of preliminary trials, the operator will most quickly ascertain when he *has got all out of a plate there is in it.*

Fixing.—At the close of development the plate is not yet ready to endure daylight. The residue of chemical salts must be removed, and all further changes arrested. This process is called *fixing*, and the routine solution is called "hypo" for short. Do not put the plate directly from one tray into the other. Hold it under the cold-water faucet and rinse it on both sides. Then drop it into the fixing bath and cover it from light. Always have the film side uppermost if using a flat tray, but the best fixing bath holds the plates edgewise in vertical grooves.

During *fixing* the tray does not need watching or rocking, and it requires from twenty to thirty minutes to thoroughly complete the process. When the film of the plate is first put into the hypo, it is white to *direct* observation, although black to *transmitted* light. In the hypo the white is eaten away, and gradually becomes black. Until the last trace of white disappears the plate is not fixed. It does no harm, but is well on the safe side, to leave the plate an extra five or ten minutes in the hypo. If taken out too soon, it will in time stain yellow and deteriorate. Use the formula supplied with your plates.

Washing the Plate.—The final finish of the plate consists in washing it. Do it *thoroughly.* The thoroughness with which a surgeon washes his hands is not less complete than the thorough washing a plate requires to cleanse it from lingering chemicals. For this reason, and to avoid tax upon the operator's patience, an *automatic* washing process is indispensable. Lift the plate from the hypo, rinse it in plain water, and, if in no hurry, put it in the washing tank with running water and let it alone for a couple of hours. Then remove it, place it in a drying rack, and let it dry at its leisure.

If the picture is wanted in haste hurry the washing by gently rubbing the film with absorbent cotton while holding it under running water. A plate can be hurried through the washing process in twenty minutes or less, by the personal attentions of the operator. It can then be dried very quickly (in half an hour or less) by placing it in a dry-room in front of an electric fan. Until the plate is thoroughly dry it is not ready to file, but can be examined for diagnosis, if necessary, before these final steps are completed.

Studies in Defects.—When the beginner has his first completed negative before him he will ask whether it is a success or failure. Between the two may fall much of the early work of the novice, and, to assist him in recognizing wherein a plate varies from success, he must study the more common faults and how to rectify them. Photographic primers, which may be had at any supply store, give the routine directions for treatment. After reading them go to the darkroom with some practical friend and see him demonstrate the procedures. We leave the subject here for matters of far greater importance in which instruction is much more difficult to obtain.

Prints from Negatives.—In general the negative is the basis of diagnosis. Prints do not always seize every detail of the negative nor do they afford information by transmitted light. Occasionally a print may give some information that was overlooked in examining the negative, and for distribution, public exhibition, and various other reasons the making of a print is a natural corollary to the radiograph. For fine detail, and especially for reproduction, the print should be made on a glossy paper. Matt papers are not suited to X-ray pictures. A good negative will make a good print on almost any good paper, while a poor negative cannot be made good by any kind of paper. The choice is somewhat affected by the intended purpose for which the print is made. If the beginner takes up the subject of printing it is easy to sample various kinds and suit his own taste. If the negative is turned over to a photographer for printing, he will be apt to use the papers he has in stock. Special papers are continually being introduced, and samples and information concerning them may be obtained from photographic supply stores.

As any single print from a negative may vary from another or show less than another, it is best to make several prints in important cases if the diagnosis is not made from the negative and a print is needed. All who have had their portraits taken will recall how various the effects of a dozen prints may be.

Who Shall Do the Surgeon's Developing?—Is there need of experience in photography in order to become an expert in radiographic work? That depends upon what the radiographer *desires to accomplish.* Many a man who never pressed the button of a Kodak has made good X-ray pictures, and many a man has succeeded in developing, washing, and fixing his first X-ray picture without any previous knowledge of the dark-room. But unquestionably "knowledge is power," and the student of photo-chemistry can soon surpass the surgeon who simply exposes an X-ray plate and develops it by the formula printed on the box.

Along with this question is the important one, "Who shall do the surgeon's developing?" So much depends on the development of the X-ray plate *by the man who alone knows what anatomical shadows he is aiming to bring out* that every operator must do this part of the work himself, or have it done at hand by a trained office assistant who participates in the handling of the patient; or an outside developer *must be told the nature of the case and what is expected from it.* There is hardly any disagreement on this point among practical workers who seek diagnostic results and not merely exhibition pictures. They not only feel the necessity of submitting to the tax of the dark-room, but it is obvious that to fail to do so is to lose part of the instructive information to gain which the radiograph is made. The argument that it is a great advantage for the physician to develop the plates himself and thus be able to learn the results at once instead of losing time by sending the plates to a photographer, is not the great argument that takes the operator to the dark-room and keeps him there with the devotion of an enthusiast. He soon learns that diagnostic developing requires a knowledge of the case, and the condition exposed, and he who does not possess this knowledge cannot know what his plate is doing. Moreover, it is work that is full of interest, and every true artist is an enthusiast.

Some surgeons have felt that a skilled photographer should be able to develop their plate much better than themselves, and this would be true in cases of no previous experience provided the photographer could be supplied with what he usually lacks, viz.: the surgeon's training in anatomy, pathology, diagnosis, and X-ray shadows. The best plan is for the surgeon to let an office assistant study what is needed of photography, and then have this assistant make the exposures and do the developing under the surgeon's direct supervision.

Over and over again beginners have thought to save the trouble of developing, have carefully made adequate exposures, and sent the plates to a professional photographer only to be told a day or two later that there was *nothing on them.* This has repeatedly happened to me during an emergency when my own facilities were interrupted. Amateurs with the ordinary camera have the same experience.

While it has been well said that failures in scientific work are often the greatest and most efficacious teachers, yet a photographer's failure to develop a plate correctly will teach nothing to the surgeon. A knowledge of what to avoid is likewise of great importance, and without more or less knowledge of photography the X-ray worker will lose valuable experience and advance slowly.

Possibly the question of *development* may ultimately prove to be one of the most important in X-ray progress. There are those who think so. The camera photographer will note the great difference in the proportions of restrainer which the experience of several years has taught radiographers to use. The camera photographer seeks a different sort of picture. He want soft lights and half-tone; radiographs seek contrast of densities. His negative is made with reflected light; the radiograph is made by transmitted light. He knows three grades of light in the negative—high light, half-tone, and shadow; the radiograph knows but two, half-tone and shadow. The radiographer instructed by experience puts into his solution five times the alkali and ten times the bromide used in portrait work and uses more reducer. The routine professional cannot comprehend the rationale of the X-ray developer, and often looks at some of the formula aghast. But it may be that in the near future still more suitable combinations can be worked out which will lend to images qualities that are so far lacking in radiographs.

CHAPTER XV

SELECTED OPERATIVE TECHNICS

Technic for Radiograph of the Carpus. Methods for Spinal Exposures. Technics for the Œsophagus. How to Remove Coins from the Œsophagus. Pelvic and other Measurements. Special Hints. To Preserve Contour of Soft Parts. Sinuses. Technic for Foreign Body in Eye with Davidson's Head-Rest. General System for Position of Patient. Technics for Chest Fluoroscopy. Intercurrent Radiography During Fluoroscopic Inspection. Technic for Cardiac Exposures. Exposures of the Chest in Pulmonary Cases. The Rheotome Method. Technic of Instantaneous Thoracic Radiography. Studies in Same.

To secure that mastery of technical methods in their entirety, which will at once enable the operator to adapt the most convenient as well as the correct technic to any given case, the general subject as taught in these clinics should be studied as a whole. Certain principles noted in one chapter will often be applicable in other directions and other branches of work; therefore a complete reading of the entire course should begin the special study of any particular department of X-ray practice. Having done this we will now take up the study of such selected operative methods as will specially impress local procedures on the mind and simplify some of the most important details of daily needs.

Technic for Radiograph of the Carpus.—To secure the most complete information regarding an injured or diseased part, it is the rule to also make an exactly similar radiograph of the opposite normal part for purposes of comparison.

First Method.—Prepare two five by eight films or plates in the usual wrappers. Place the author's Position-Finder on the stand or table at the convenient height for the patient. Centre the tube at twenty inches vertically over the indicated centre as marked on the metallic base. When ready to excite the tube for the exposure, bring in one plate and place it on the base which automatically locates its centre directly in the axis of the ray. Upon the plate now place the injured carpus with the centre of the diagnostic field as indicated by the clinical examination, and previously marked on the skin, directly upon the marked centre of the negative, so that *the long axis of the part is at right-angles to a line drawn across the centre of the plate.* Make the exposure as usual, remove the part and plate, bring in a second plate, and place the other hand in exactly the same position on it. Repeat the exposure. Develop both plates with the same treatment, and for study lay them side by side on the examining-box described elsewhere.

It will be seen that this method does away with much of the trouble of techniques ordinarily described, which direct the operator to first place the part upon the negative and then adjust the tube with relation to the part. A single large plate can be used, if preferred; the first hand being taken on one-half of it while the other half is protected during the exposure by a sheet of lead. As a very slight change in the relative position of the wrists in the two exposures will produce an equal difference in the radiograph, the importance of automatically and instantly locating both plates in exactly the same position and centrally under the axis of the rays, is obvious. By also using the author's distortion landmark, the proof of an axial exposure or any deviation from this will be shown in the negative beyond dispute.

The method of early days of placing both hands side by side upon a plate and placing the tube over the line between them is too inaccurate for diagnostic purposes. One thing at a time is all that can be rightly done, and it is impossible for the correct axis of the rays to be in two places at once. To properly radiograph one diagnostic field at a time must suffice.

Second Method.—Remove the depthing rod from the author's examining frame and level the markers. Secure an axis of the rays in the right-angle at the foot of the markers. Insert the part so that the centre of the diagnostic field will press against the point of the front marker. It will then be exactly in the axis of the rays and be imaged without "distortion." Next slip the photographic plate between the part and the frame and proceed as before with the exposure. A second plate with the normal carpus for comparison is next readily exposed in the same manner. The correct axis of rays is maintained by the frame for as many exposures as may be desired. The tube needs no changing when once stationed, and the frame is levelled to its focus. The entire technic presents a maximum of accuracy with a minimum of care and trouble. The same method applies equally to exposing the elbow, shoulder, or any exact section of the upper extremities. It is of universal convenience and application.

To keep the shadow of the markers from the negative simply slip the rear bar aside during the exposure. The act of placing the plate inside the front marker prevents its appearing in the picture. If either marker (or both) is required in the negative for landmark purposes simply leave them in position and place the plate outside the front of the frame instead of within it. If a circular outline of the small field is desired to show in the negative change the rod markers to the pair of *rings* and proceed as directed before.

Methods for Spinal Exposures.—Luxations and fractures, scoliosis, congenital anomalies, ankylosis, tumors, especially gummata, tuberculous spondylitis, etc., have all been repeatedly diagnosed by the aid of X-rays. The posture of the patient will depend somewhat upon the location and suspected character of the lesion. Spinal bones, when placed in closest contact with the plate, will show nearest life-size, and in some respects will thus yield the best definition. If radiographed at a distance from the plate so great as the thickness of the body the relative enlargement and diffusion of the shadows will vary according to the mass of the individual and the distance of the tube. The effects obtained with a little child, or an emaciated adult, with the abdomen on the plate, will be in striking contrast with a radiograph of a corpulent man with the tube at the same distance in both cases.

The cervical vertebræ may be radiographed anteriorly or from either side. For special local pictures of the neck use a narrow plate which will fit in and press closely in contact with the part.

The dorsal vertebræ may be radiographed anteriorly or at a right or left oblique angle.

The lumbar vertebræ may be radiographed in either anterior or posterior position.

No great *extent* of the spine can be *correctly* radiographed on a *single plate,* if the object is to show the condition of local vertebræ. By reference to the author's divergence chart, accompanying this book, it will be seen that practically but one vertebra will occupy the exact field of the central axis of the rays, and that with the tube at twenty inches only one additional vertebra above and below the axis-centre (three in all) will be defined with a *minimum* of departure from a right-angled shadow. Above and below these correct diagnostic fields the slant of the rays will cause increasing overlapping of the shadows and lessen the value of the picture in proportion to the distance from the centre.

In making a radiograph with a view to observing conditions lying in front of the spine near the anterior wall the patient should always be placed face downward for two reasons: by removing the spine to the greatest distance from the plate its shadow is thinned and spread apart, and by bringing the object for diagnosis nearest to the plate its shadow is concentrated and best defined.

For *recumbent* exposure centre the plate with the author's Position Finder first laid on the table with the tube over it at a minimum of twenty inches. With an efficient tube the distance may preferably be thirty inches if the subject is thick and the avoidance of even a small degree of magnification is desired.

Mark the centre of the plate on the envelope wrapper and mark the skin at the site which should be aligned in the exact axis of the rays. Then place the patient on the plate with the marked spot in contact with the marked centre on the envelop, and all is ready for the exposure. No other adjustment is required. Make the exposure and proceed as taught.

For *erect* positions use the author's examining frame to secure the path of the axis of the rays. Level it with the marking rods in the middle of the frame. Mark the centre of the envelope wrapper. Put the plate in the frame so that the glass back presses against the front posts and the marked centre agrees with the front axis-marker. Then slip in the patient so that the marked spot on the skin (the centre of the field to be skiagraphed) presses against the plate on the marked centre. Slip off the rear marker to keep its shadow off the plate and proceed with the exposure as taught. Any number of plates can be set in the same position for duplicate exposures without changing either tube or frame. The mechanical simplicity of the technic is perfection. A right-angled picture must always result from this method, as there can be no "distortion" when the part is radiographed in the exact axis of the rays. This fact cannot be too strongly impressed upon the mind.

Technics for the Œsophagus.—The least satisfactory technic for the detection of foreign bodies in the œsophagus is that which places the tube directly behind the spine and the plate or fluoroscope in front of the sternum. Avoid this.

Seat the patient upon a sufficiently high stool with all superfluous clothing removed from the trunk of the body. Adjust the tube at the level of the field to be examined and start it into action. Now partly turn the patient so that the fluoroscope is in relation to the right side of the front of the body while the rays come from the left of the spine behind. This *oblique* position of the body *will carry the shadow of the spine to one side of the line of œsophagus so that foreign bodies in its canal are projected on a clear field.*

The following aids to the diagnosis of stricture of the œsophagus are combined with this technic:

1. Have the patient, at the time of the examination, swallow two drams of bismuth in about four ounces of water. If a tight stricture exists the water is stopped at the point of constriction, the bismuth settles against the walls of the œsophagus, and the shadow is readily observed with the fluoroscope.

2. When actual stenosis does not exist as tested by the solution have the patient swallow a capsule or wafer of bismuth (or containing a shot) while the examiner inspects the chest with a fluoroscope. If the result is positive the shadow will be seen either stopped and remaining in the same position for some time, or else moving downward very slowly.

3. When the failure of the above methods demonstrates a still larger calibre of the stricture have the patient swallow some article of food which he knows from experience will lodge, and then on top of this swallow the loaded capsule and the fluoroscope will complete the diagnosis.

In the case of a spasmodic stricture the behavior of the tissues in speedily rejecting the capsule or whatever was swallowed would point to the character of the lesion. After examinations with a fluoroscope a radiograph can be taken if desired. If difficult to obtain a view in other positions, turn the patient more sideways to the tube and incline the body toward the tube. Then press the fluoroscope high in the axilla with the shoulder elevated as much as possible.

How to Remove Coins from the Œsophagus.—Edwards reports:

"During the last two years eighteen cases of coin in the œsophagus have come to my notice. In five of them the coins have been lodged for periods varying from five weeks to three months without serious consequences. They were all situated in the same position; namely, on a line with the top of the sternum, and the face of the coin was in each instance turned forward. With the exception of the first case which came to my notice, and which was removed by operation, they have one and all been removed by means of the coin-catcher within a few minutes of their positions being ascertained with the X-rays.

"It is a pleasure to be able to praise a surgical instrument which is generally believed to be useless. This instrument (the coin-catcher) is absolutely certain to achieve the results for which it was designed if properly used. It consists of a whalebone stem in the ends of which is fixed a piece of watch-spring. On the ends of this, on a loose hinge, is fixed a miniature anchor which moves freely from one side to the other. When this is passed down the œsophagus, which contains the coin, and past the obstruction, one of the free arms passes beneath and behind the coin, so that when the instrument is withdrawn one arm grips the coin and brings it up.

"Until the discovery of the X-rays the coin-catcher was generally held to be a useless instrument, many surgeons preferring to operate rather than to try it. The positive knowledge which is gained by means of the fluorescent screen has, however, taught us that it can render invaluable aid. In several cases which have come under my notice the coins have been in the œsophagus for a lengthy period with but slight apparent discomfort to the young patients, hence there existed much doubt as to the presence of a foreign body at all, and it was only after the application of the X-rays that the diagnosis was made a matter of certainty.

"The difficulty in all cases in ascertaining the presence of a coin without the X-ray leads me to ask: What became of such cases before the X-ray? In all probability many patients died without the exact cause having been discovered. A coin left undisturbed would undoubtedly slough through into the trachea and the patient would die from a septic pneumonia. I have no doubt that many lives have been spared by the use of the X-rays, and have no hesitation in recommending the coin-catcher as a most useful and most efficient instrument."

Pelvic and Other Measurements.—When observed on the fluorescent screen or fixed on the negative plate any shadow of an object is magnified in proportion to its distance from the screen or plate, and the space between it and the tube. To reduce the shadow to the true dimensions of the body ordinarily requires some figuring.

It is sometimes desired to know the real size of a bullet or other foreign body buried deep in the tissues and an example of references to the reduction of pelvic enlargements is the following, taken from the *British Medical Journal:*

"The authors place the patient horizontally over a plate twelve by sixteen inches in size and adjust the tube vertically over the centre at twenty inches height. The exposure is then made and the plate developed. The shadow of the pelvis is measured, and as the distance from the tube to the plate is known the pelvic dimensions can be accurately computed. To facilitate this Levy has designed an instrument on the principle of the pantagraph by which the true conjugate can be mechanically determined. The transverse diameters at the brim and outlet can be estimated with equal certainty, and the method has been satisfactorily tested in Landau's clinic."

The automatic and graphic reduction of magnified shadows to their just proportions is one of the functions of the X-ray Divergence Chart which supplements this course. The process has the advantage that it requires no computations or figuring of any kind.

In the case of a bullet, and taking twenty inches from the anode focus to the centre of the plate as the standard working distance, make the radiograph as usual. Get the depth of the bullet (also without figuring) by means of my examining frame, and the two red lines which mark the width of the shadow at the twenty-inch cross line show the true width of the object at its height above the cross line. A pair of dividers may be used to take the diameter of the shadow, or a strip of paper may be laid on the negative and a pencil mark made at the centre of the plate, and at each side of the shadow of the bullet. Lay this strip on the twenty-inch cross line and a glance up the two red lines to the equivalent of the depth of the bullet, say two inches, will instantly reduce the diameter to that of the object sought. The measurements are self-evident and are made at sight.

Having a negative or print of the pelvis taken at the standard distance of twenty inches, the twenty-inch cross line of the chart shows the dimensions of the magnified shadows. To reduce them to normal the cross line at the height of the brim above the plate will show the true diameters. By centering one leg of a pair of long dividers on the central line of the chart and spreading the other point till it reaches the red line which marks the true brim, we obtain a correct radius. Then place the dividers on the print or negative with one point at the centre and mark a circle. This circle will indicate the proportions of the brim reduced to actual size.

Whether determining diameters at the brim or outlet the deviations from a horizontal plane can be corrected and the true diameters read at sight on the chart by taking the readings from the converging red lines at the distances above the twenty-inch base line, which agree with the actual perpendiculars of the pelvis being measured. By a few moments' use of a rule, a pencil, and pair of dividers, a print of the pelvis can be marked with circles at the brim and outlet, and with cross diameters which shrink the shadows to the size of life. The dimensions in figures can be written on the lines and a permanent record obtained. Those particularly interested in the subject could no doubt work out other details.

Some aim to get the unmagnified size of the pelvic brim by covering one-half of the plate with lead, placing the tube vertically over the edge of the opposite side and taking the half in one radiograph; then repeating the process on the other half. The result may or may not be satisfactory, but requires two exposures and yields a broken picture. A single exposure with a centrally focussed tube produces an evenly magnified shadow which the Divergence Chart instantly reduces to normal size. Mere mention of the two methods suffices to show which is best.

"The value of the X-ray in obstetrics," both during pregnancy and in the abscence of gestation, has been investigated by Dr. Mullerheim, who maintains that by their aid the various forms and degrees of pelvic deformity, such as arise from rachitis, esteo-malacia, and spondylolisthesis may be detected and appropriate treatment instituted in case of subsequent pregnancy. He says:

"It is possible by this method to determine accurately the distance between the posterior superior iliac spines, the breadth of the os sacrum, the distance of the lumbosacral crista spinosa from the posterior superior iliac spines, and the distance from the middle of the promontory of the sacrum to the sacro-iliac symphysis. Not only can the presentation of the fœtus be determined, but also the size of the fetal head and the dimensions of the pelvis."

Freund has found that placing the patient in the Trendelenburg position was a great improvement in radiographing the pelvis, as then the vascular intestinal coils fall toward the abdomen and to some extent the field is more clear for the passage of the rays.

To Preserve Contour of Soft Parts.—In making stereoscopic or even plane negatives of any part of the extremities with a view to present the bones in relief within the rounded body of the tissues, it is necessary to preserve the muscle-masses from over-exposure. To preserve the outlines of the arm or leg while showing the interior bones so that the parts have the surface contour visible fill the meshes of a roller bandage with bismuth powder and apply to the part. The bandage will assist in holding the image of the surface contour while the bones are being penetrated. Make sharp, quick exposures.

To make the negative show fine markings of the skin of any thin part moisten the skin, dust on the surface a little bismuth powder, and partly wipe off the surplus. Then make a short exposure.

In all exposures with a view to showing the soft tissues plainly make short work of it, and have the tube neither too close nor too penetrating. It is not easy to lose the shadow of a bone by over-exposure, but it is very easy to lose the best effects of soft parts by too much penetration of the rays. A little experience is the best teacher as to exposure-time.

Sinuses.—To demonstrate the course and extent of sinuses and abscess cavities in a radiograph when they are accessible for injection, inject into them a solution of one part of bismuth subnitrate to two parts of glycerine. This will cast a darker area of shadow than the adjacent soft parts. Even water will cast a shadow among soft parts and may be used to inject a sinus. Iodoform has been used, but is open to objections for some purposes.

Injecting Arteries for Radiographs.—In anatomical studies of the circulatory system excellent results have been obtained by injecting the body with a mercurial salt, and also with heated compounds of triturated Chinese vermilion in a fatty base which hardens on cooling. Many studies have been made by special workers with a view to class instruction. The smallest vessels show beautifully in the negative when injected with a fluid opaque to the rays.

Gaseous Inflations of Hollow Viscus.—Air is much more transparent to X-rays than any tissue or fluid of the body, and, reversing the principle of injecting a dense compound, we may inflate certain hollow organs with transparent gas, and thus make a light contrast with denser bodies around them.

The intestinal tract offers the chief field for this method. The stomach may be distended both for the purpose of detecting a darkened area by contrast if part of its wall is thickened by disease, or to remove or define its borders to observe conditions about adjacent parts, such, for instance, as the pancreas. If the stomach and lower bowel are inflated the outline of the spleen is better defined by its contrasting density. The rectum, sigmoid flexure, and descending colon may be traced when distended with air by their light course amid darker surroundings and in addition to direct effect on the inflated gut the examination of adjacent organs, as the left kidney, may be facilitated by the contrasting lightness of the margins. An internal tumor also may suggest that the lower intestines be inflated to bring out the darker shadow of the solid body. Refinements of these kinds in X-ray examination belong to the work of the expert, and are useless till skill in interpretation of shadows is developed.

Technic for Foreign Body in Eye with Davidson Head-rest.—The object of this head-piece is to secure the absolute immobility essential to the localization of a pin-head body in the eye.

Place the frame on a table at such a height that the head of the patient sitting comfortably in an ordinary chair will adjust itself to the side of the frame, right or left, as the case may be. With a piece of adhesive plaster secure a section of fuse-wire one centimeter long in the centre of the lower lid—vertically—so that the upper end has a known relation to the eyeball. This furnishes the base from which the location of the buried body is found. Next fit the side of the head with the injured eye flatly against the window of the frame which receives the plate, so that the horizontal metal rod crossing the field of the window will be on a level with the lower lid. Next adjust and screw fast the chin and head clamps so as to hold the head *fixed* in the secured position. Connect the tube in the arm of the frame which slides horizontally to the plate and focus the rays at right-angles to the point where the cross-wires of the window intersect. Measure the distance exactly. See Plate No. 14.

Test the working of the tube, cut out the current, and bring in one 5 × 7 plate in the usual wrapper. Insert the plate in the open window and close and clamp fast the hinged-door so as to press the film well up to contact with the temple. When all is ready for the exposure instruct the patient to close the eyes and direct the vision to a small point some feet in front, level with the horizontal rod and parallel to it.

Now quickly move the sliding-arm of the tube-holder three centimeters to the right of the previously centred focus and make the shortest exposure which the capacity of the tube will permit. Less than a full minute is best. As soon as the first exposure is made cut out the current and quickly shift the arm holding the tube to a position three centimeters to the left of the central focus, which will be six centimeters from the focus at which the first exposure was made. Then on the same plate and with no change of the patient, keep the eye in the same visual axis and make a second exposure equal to the first.

Cut out the current when done, remove the tube, unclamp and release the patient, let down the door of the window, and take out the plate on which the two exposures were made. Develop the negative in the usual manner, and it is at once ready for the final step of localization. Two separate plates are used when a stereoscopic picture is desired, or two can be used always instead of one as described.

To determine the results employ the cross-thread apparatus as elsewhere described; then place the patient facing you in the exact position he occupied when skiagraphed, and apply the measurements made on the plates. The foreign body will be the measured distance to the nasal or temporal side of the upper end of the external fuse-wire, the measured distance up or down, and the measured distance backward from the point arrived at parallel to the visual axis. The trained ophthalmic surgeon can at once show the situation on an eye-chart and can cut down and remove the particle of steel as precisely as if it were a bullet in the leg. As done by the expert it demonstrates the limit of scientific precision in localization and is quickly done, but the novice or one who is not trained in ophthalmic work will be puzzled to use his pictures after he has made the exposures *secundum artem.*

Davidson has personally demonstrated the marvellous accuracy of his method in more than 300 cases, some of them locating pieces of steel so small as to be scarcely visible to the eye and often buried in opacities that would have defeated search for them in any other way. He has made eye-work as precise an art as the measurements of a surveyor.

General System for Position of Patient.—To render the interpretation of radiographs easy, and to avoid as much as possible distortion of the shadows, a London surgeon makes the following suggestions relating to exposure technics:

"1. There should be certain points on the human subject over which the anode should be placed, and on the negative a small mark should denote the position of the focus.

"2. The distance from the tube to the plate should never be less than eighteen inches. (Twenty inches would be a good general standard.)

"3. In radiographing the lower extremities they should be placed at a right angle with a line drawn between the two anterior-superior spines of the pelvis, and the spinal column should be absolutely at right-angles to this cross mark.

"4. In the upper limbs: for the shoulder-joint, the arm should make an angle of forty-five degrees with the mid-line, and the hand should rest with the palmar surface downward. The opposite sound part should always be shown for comparison, taken, of course, under exactly the same conditions. In the elbow-joint the internal condyle being on the film, the anode should be placed over a point about an inch below the external condyle in the line of the forearm. This is for the purpose of opening up the joints as much as possible.

"5. For the trunk, it should be placed as symmetrical as possible, and for the cervical vertebræ the best position is with the occiput well over the end of the film or plate and the chin high up, but exactly in a straight line with the sternal notch. What is really needed is that all X-ray workers should have a fair knowledge of anatomy, especially of bones and joints, and have *a system of uniformity* for skiagraphing the several parts of the body. This system should be known to surgeons in general so that they will be able to adequately interpret the works of any particular operator."

A *System* of almost universal applicability and of a mechanical simplicity comparable with that of focussing an opera-glass is presented in the author's Examining Frame. It makes no complex demands on technique. It taxes the memory with no cumbersome details. It does not require the mastery of different methods for different parts of the body. It is adapted both to exposures in the perpendicular and at any angle outside the direct axis. It involves only two acts:

1. The securing of the field of rectilinear radiance. The act of levelling and sighting the frame does this almost instantly, and, once levelled, the frame holds the field for any use *on any part of the body.*

2. The placing of the part in the field in the frame.

The act of placing the part in the frame is almost as simple as putting the foot into a shoe. We assume that the examiner starts out by knowing what part of the body he wishes to examine; that he can conveniently locate and mark the exact spot on the nearest surface of the patient's skin; that he can put that spot exactly on a marker in the frame, just as he could put one penny on top of another; then, having done this, the relation of the opposite surface of the part and the focus of the tube need no plumb line or attention whatever for they fall automatically into their correct relation with the entire part through the mere act of placing the part in the frame. Study of this simple method will repay surgeons.

Technics for Chest Fluoroscopy.—The examination of the thorax with a fluoroscope with the patient sitting or standing is divided as follows:

1. *Anterior inspection.* Screen in front of the thorax.
2. *Posterior inspection.* Screen upon the back of the patient.
3. *Right lateral inspection.*
4. *Right anterior oblique inspection.*
5. *Left lateral inspection.*

Remove all superfluous clothing from the trunk of the body. Adjust the fluoroscope in the examining frame. Arrange the tube so as to leave four inches space between the tube-wall and the surface of the patient's body. Level the tube and frame to secure the fixed diagnostic field as taught. Have the patient erect, either standing or sitting. Next bring the patient's thorax within the frame and field, and in close contact with the fluorescent screen. While pressing the fluoroscope against the patient, with one hand outside the field press the patient forward upon the screen so as to secure the best possible contact. Either by regulating the action of the tube or by *increasing the distance between the tube and the patient* secure first the degree of illumination which affords the best contrast of shadow with the given case. As no two cases are alike in substance, thickness, density, age, etc., the regulation of the illumination of the screen is of primary importance.

Beginning with one apex gradually move the entire area to be examined through the bounded and stationary diagnostic field, which does not change its position or deviate from the axis of the rays during the entire process. Any one who has witnessed the random and unscientific inspection of the chest in the ordinary manner will appreciate the precision imparted to the process by the fixation of the fluoroscope, the diagnostic field, and the axis of the rays. During the steps of inspection have the patient at one time make deep *in*spiration and hold the breath as long as possible, so as to keep the organs still. Next, inspect during forced *ex*piration. Also during regular *deep* breathing and regular *average* breathing. Also with the arms in different positions, especially with them both *extended upward over the head to clear the upper regions of the lungs from the shadows of the scapulæ.* These clinical posturings during the examination must be directed by the physician according to the object of the examination, and experience will suggest those best adapted to different cases.

While noting that the excursion of the diaphragm is altered by any state of disease that limits expansion remember that the normal dimensions of the chest vary, and that a short chest will have a shorter rise and fall of the diaphragm than a long chest. Allowing for this normal difference have the patient sit still and breathe quietly, and then mark on the skin of each side the high and low limits of rise and fall. Then have the patient take several energetic and deep breaths. Immediately mark the maximum rise during forced expiration and the maximum descent on deep inspiration.

In observing bones or bullets with the fluoroscope the degree of radiance employed may vary within wide limits and yet permit the diagnosis. Not so with examinations of the thorax. Faint shadows which can be caught with just enough light may be lost with too much or too little. Therefore, during the view increase and diminish the dosage of the tube to cover every possibility of shadow detection. For this purpose it is convenient to arrange the means of current control within reach of the hand without taking the fluoroscope from the eye.

By the simple yet efficient aid of the author's examining frame to retain the axis-path of the rays during all movements of the parts successively into the field the technic is reduced to mechanical accuracy. The sole remaining exercise of judgment relates to the regulation of the dosage of radiance. Practice the principles as taught in these lessons, and skill in diagnosis will rapidly develop along correct lines.

Intercurrent Radiography during Fluoroscopic Inspection.—If at any given point in the field the fluoroscope detects an apparent condition which you may desire to *radiograph* for finer definition simply tell the patient to sit still with the same field against the frame, unclamp the fluoroscope, slip in a plate, make the exposure, set aside the plate for later development, return the fluoroscope to the frame, and resume again the screen examination till it is completed. No other technic enables this to be done in so simple a manner, with perfect convenience to the operator, and no disturbance of the position of tube or patient.

Another Method.—An author who has made a very large number of X-ray examinations of the chest thus states the method he employs.

"During X-ray examination most of my patients lie on a narrow canvas stretcher, and the anode of the tube is placed three feet away when the thorax is examined, and usually under the point where the median line is crossed by a line joining the nipples. This position should be determined by plumb-lines. The median line is obtained by sighting from a permanent plumb-line that is fastened to the middle of the support upon which the head of the stretcher is placed to another fastened to the support at the foot in the same way. The other line is determined by putting a string eight feet long with a weight on each end across the chest from nipple to nipple at the level of the fourth rib. This line hangs down on each side of the patient, and the proper point is obtained as before by sighting from weight to weight. The patient should lie flat on his back, and care should be taken that one side of the body is not higher than the other. A small level may be placed across the sternum for this purpose.

"In all examinations of the heart it is important to have the light just right, so that the shadow of this organ may be brought out sharply and clearly. In young patients it is necessary to be careful not to have too much light, as then the border of the heart is not well defined. If the apparatus has a suitable means of adjusting the current to the tube the amount of light required is readily regulated."

Experts doing careful work on lines similar to the above will find the author's examining frame a great saving of trouble. Compare the two methods and note the simplicity of the frame.

Technic for Cardiac Exposures.—Ordinary directions state that the best picture of the heart may be taken with the plate upon the chest and the anode of the tube two inches to the left of the sixth dorsal vertebra. All directions for posture in radiography, which depend on securing a correct position of the tube *after* the part is placed on the table or plate, make difficulties for the operator and leave accuracy to guesswork. The aid of a mechanical device which adjusts the tube to a centre on which the part can then be accurately placed removes error and simplifies scientific technics. The author's examining frame does this. *Align the markers near the centre of the frame.* Focus the tube at twenty inches from the distal marker with the frame suited to the cardiac level when the patient sits erect on a chair with the body sidewise in the frame. A single moment suffices to make this arrangement. It is as simple as sighting an opera-glass.

Next sit the patient on a chair with the chest in the frame. *Guide the body up to the anterior marker till the exact centre,* or apex, or base, of the heart—whichever you wish to be the centre of the radiograph—*engages in the angle of the marker.* It is done as simply and as quickly as you would place your finger tip on the patient's nipple. It secures the exact position instantly. Next, *slip off the markers* from the frame and slip in the photographic plate. *Make the exposure.* The plate can be backed with the brass cut-off and used with or without an intensifying screen, as desired. Another exposure can be made at once with the patient reversed, and without altering the exact focus *secured and maintained by the frame for as many exposures as may be wished.* The absolute superiority of this method over all others will be apparent on a single test.

The same posture without the plate is the correct position for examinations with the fluoroscope. Clamp the screen on the frame and the heart will be seen in the right place and alignment for the best view.

By this method one border or any desired point about the heart may be put in the path of vertical rays and examined without magnification. For method of tracing the heart outline on the skin or on record blank, see description of author's instrument in Chapter XI.

Radiograph of Chest with Patient Recumbent.—While pulmonary cases are for the most part radiographed in an erect posture (as will presently be taught), yet the recumbent position may be required in a given patient. To picture the general field of the upper portion of the thorax on both sides proceed as follows:

With the author's Position Finder centre the tube at thirty inches vertically over an 11 × 14 plate. Lay the plate on the base of the P. F. as taught. Remove all clothing to the belt and place the patient face down and flat on the table with the centre of the upper part of the thorax in the closest possible contact with the film at the centre of the plate.

Have patient *extend both arms full in front.* This forward extension of the arms removes most of the shadow of the scapulæ from over the lung-tissue and clears the field as nearly as possible. Direct the patient to maintain a full inspiration as nearly as possible during the exposure.

To picture a local field in the thorax in a similar manner centre a smaller plate at twenty inches. Strip the chest, examine, and mark on the skin the area of suspicion. Then lay the patient on the plate so that the centre of the essential diagnostic field will be on the centre of the film. Make the exposure as above.

To avoid blurring of definition from respiratory movements a ready method is to have the patient take a deep breath at the beginning of exposure, hold it as long as he can, and signal when he is compelled to breathe again. Then cut off the current while respiratory relief is secured. Then switch on the tube again with the chest inflated as before. Repeat till the exposure is complete. Or, the patient can be allowed to take a breath as quickly as possible without stopping the tube. In either case the object is to secure a sharp detail by a short exposure during which the chest muscles undergo the least possible change.

Movement of free respiratory actions or the slightest twist of the body, or the vibration of a tube in an unsteady support, will tend to blur the lines and dim the definition of the shadows. Use the utmost endeavor to secure fixation of the part while the rays are active and aim at a short exposure. Fat streams of rays from coarse twelve-inch coils and from thirty-inch Static machines, having from sixteen to twenty-four *revolving* plates, will secure a good negative in two minutes. Medium apparatus will require five minutes. With special film between two photographic screens chest pictures have been taken in one second; in a few seconds; with one screen in one minute; by different operators. Less efficient apparatus which requires ten minutes for the chest does not appeal to the expert, as the difficulty of producing clear outlines of parts so subject to variation of position increases beyond control with long exposures.

Several operators have suggested measures for minimizing these difficulties. One has constructed a switch moving synchronously with the respiratory muscles so that when the patient breathes the current is cut off. With the author's short-circuit stick the tube excited by a Static machine can be cut in and out to the same end. But the best road to fine skiagraphy of the chest is high-efficiency apparatus, rapid films, controlled respiration, and short exposures.

As shadows caused by structures outside the thoracic cavity must be distinguished from those produced by the internal organs the difference between muscular folds in very muscular persons, and the entire absence of them in cases of emaciation must not be overlooked. In this form of posture the axillary fold in front close to the plate often photographs very distinctly. Owing to the respiratory movements of the contents of the thorax the record upon the plate has some unavoidable defects, and, if the *stereoscopic fluoroscope* is shortly brought to a simple, inexpensive, and convenient state, it is probable that few radiographs of the chest will be made. With such an instrument the operator could see the cavity *in situ*, could see the heart as a muscular body and not merely as a silhouette, and could note the contour of new growths and enlargements.

We will next study an arrangement for securing the *effect of fixation* of the respiratory muscles and organs so that they may be radiographed under as favorable conditions of rest as a joint. This is accomplished by an intermittent action of the tube so that the exposure is shut off while moving the lungs to get air, and only acts on the film at the one desired stage of respiration. This is for time-exposures which take more than a minute, or several minutes. The intermittent activity of the tube is made to coincide with the time the patient holds his breath by a rheotome device which we will now consider.

The Rheotome Method.—It was early discovered that there was a marked difference in the definition of a thoracic radiograph made during life, and after the death of the individual. In the latter, the sharp markings, the well-defined borders, the distinctness of the outlines of the heart, the diaphragm, and the extremities of the ribs, when radiographed in absolute rest, indicated how much the accuracy of an X-ray examination during life was impaired by the respiratory and cardiac movements. To place the examination of the thorax and abdomen upon an equal footing with other parts of the body, as nearly as possible, attempts have been made to *restrict the action of the rays to a single phase of temporary arrest of the function of all the organs*, save the heart. During *ex*piration the thorax is less suitable for radiography than at the maximum of *in*spiration, as the ribs are then closer together, the tissues more dense, and the reduction of air in the lungs opposes transparency. The heart also becomes overloaded and changes its shape under the increasing venous congestion, and dyspnœa.

During an exposure of the thorax the action of the rays may be limited *to the time of arrested movements of respiration*, either by alternately stopping and starting the current and the X-rays, or by alternately interposing and removing a sheet of metal in the path of the rays while the patient is allowed to breathe. But automatic apparatus has been devised by Cowl and is thus described:

"1. An easily movable, double-armed lever acts as a rheotome or automatic interrupter of the current, when so adjusted as to be acted upon by the movements of the body. By means of a platinum contact at its other extremity the current is broken at the stage of respiratory movement corresponding to the adjustment made.

"2. A small magnetic electro-interrupter actuated by a separate weak current from cells and connected with the rheotome opens and closes the circuit of the main current which excites the coil and the usual interrupter, in a purely mechanical manner.

"To obtain a given radiograph at any point of inspiration or expiration the platinum plate at the contact is adjusted against the end of the lever which is supplied with two platinum points, so that closure of the current may be had by the movement of the lever either upward or downward. By means of a set screw the closure of the current is deferred to the desired stage of respiration. In order to apply the rheotome to the proper part of the body, it is arranged on a stand with an arm which permits movement in either a horizontal or vertical direction.

"In the use of the rheotome the patient is placed in the dorsal position on the photographic plate. The rheotome is adjusted so that the lighting up of the tube, and the sound of the spark of the interrupter of the coil-current occur simultaneously with the stroke of the hammer at the small interrupter on the core of the electro-magnet. The patient is now instructed to cease breathing after each sound of this last stroke of the interrupter of the rheotome. When he has practised this and grasps the idea, the main current is switched on. The patient is then 'almost unconsciously guided to control the respiratory movement by the rhythmical action of the luminosity of the tube and the sound of the interrupter.' The entire proceeding is automatic during the making of the picture. The rheotome, interrupter, accumulator, and stand, described, are made by Hirschmann of Berlin.

"The resulting pictures are very satisfactory as compared with those of the usual skiagraph of the normal thorax, which, at all the points affected by respiratory movement, show more or less broad cloudy margins which partly, or completely, obscure important details.

"Of two pictures taken under the same conditions, and the same exposure-time, the one taken during the maximum of *ex*piration will show a marked lack of distinctness, as compared with the one taken with the lungs expanded with air. Skiagraphs of this kind, however, do not excel ordinary pictures so much when they are taken of certain diseased conditions which fix or limit the movements of the affected organs, such as aneurisms, pleuritic adhesions, spondylitis, etc. The presence of sharp outlines at the edges of the heart and diaphragm on the ordinary skiagraph suggests a deviation from the normal state, and the determination of impaired mobility of the organs and the significance of the same, can best be obtained by means of two pictures taken by the rheotome method.

"Among the details to first attract attention in *ex*piratory as well as in the *in*spiratory picture is the great distinctness of the summit of the diaphragm and the rib, especially the anterior extremity of the latter; also the sharp borders of the aorta and the heart, besides the less distinct lines of the left ventricle, blurred by its independent movement which cannot be arrested during the exposure.

The outlines of the arch of the aorta to the left of the central shadow leave nothing to be desired as regards distinctness. The two auricles are, especially in the *in*spiratory picture, sharply distinguishable from the lung; the left auricle in both pictures also being strikingly enlarged, apparently being attached to the bulbus aortæ. The shadow of the descending aorta is partly covered by the transverse processes of the dorsal vertebræ, which, from the third downward, are located progressively lower beneath the respective ribs. The heart and aorta as a whole appear enlarged in the picture.

" As an explanation of the light area between the heart and the diaphragm (barely evident in the *ex*piratory picture but clearly marked in the *in*spiratory picture) it is assumed that the right ventricle located at the diaphragm, as well as the apex, is markedly distinct from the reflection of the pericardium attached to the midriff, as otherwise the aforesaid light area of the former would appear almost like that of the lung. The light space is produced by the separation of the diaphragm from the posterior portion of the heart at the maximum of inspiration and descent of the diaphragm.

" In regard to the reproduction of the external border of the left ventricle, rheotome-pictures of entirely normal and younger subjects show varying distinctness in outline. From a comparison of the results of the rheotome method, it is considered probable that the indistinct borders of the heart in the usual skiagraph are mainly caused by the movements of respiration rather than the action of the heart.

" The rheotome method is also recommended for radiographs of the abdomen, especially when it is essential to detect the presence of foreign bodies in tissues affected by the movements of respiration.

" In making an exposure with the rheotome device the lever is applied to a part of the abdominal or thoracic wall outside the path of the rays, so that it will not interfere with the picture." (COWL.)

The next step forward aims at the effect of fixation in a different way. It calls for no ingenious mechanical device, but simply asks the patient to fix his respiratory muscles at a definite point for *one second*, while apparatus of high efficiency make an instantaneous or so-called " momentary " radiograph of the parts. It would seem that any careful student of this INSTRUCTION ought to be able to do the same thing himself after obtaining the necessary screens and quality of rapid films. The subject is most attractive.

Technics of Instantaneous Thoracic Radiography.—In the classical work of Von Ziemssen and Rieder in making thoracic radiographs with *momentary exposures during the arrest of a single deep inspiration*, the following technique is employed:

A coil with a twenty-inch spark rating.

An electrolytic interrupter.

X-ray films made by the Schleussner Company, Frankfort-on-the-Main, each sandwiched between two intensifying fluorescing screens, wrapped as one plate in light-proof paper.

A plate-holding frame adjustable to height on runners fixed to the wall. The patient standing on the foot of the device leans his thorax firmly against the vertical front of this frame with his chin resting on the upper edge. The tube is focussed to the centre of the film at twenty inches distance. After once focussing the tube and frame, either dorsal or frontal exposures may be made in the same manner. When ready, the patient takes a deep breath and *holds it*, the operator closes the electrical circuit for *one second*, and the film is then developed and treated as any other photographic plate.

As an improvement on the above add a plate of heavy sheet-brass as an opaque backing to the film, and steady and make closer the contact of the patient by a pair of side shoulder braces drawing moderately upon the subject. See Fig. 4, page 54.

Bearing in mind that the words "instantaneous" and "momentary" are employed here to mean an exposure of one full second, and not to signify exactly a "snap-shot," we will pass to the interesting study of this branch of X-ray work.

Studies in Thoracic Radiography by Professor H. Von Ziemssen and Professor H. Rieder. (Munich.)—No student of diagnosis can afford to miss the following contribution to the methods and researches of eminent men. Read it with care:

"Improvements in technique have conquered to a certain extent the difficulties of radiographing the inner organs of the body, and with this advance the practical value of the X-rays in internal medicine is assured. By their aid some of the most important physiological and clinical questions have been determined, especially since the method of "*momentary* exposure" has been employed. *Time*-exposures have their place and value, as has also the fluoroscope, and the combined methods greatly extend the range of examinations beyond previous accomplishments.

"At first the older methods of physical diagnosis seemed destined to hold their predominant place with no further aid from the X-rays than confirmation (without new knowledge) in diseases of the thoracic cavity, but the decisive diagnostic value of the rays themselves has become definitely established *by the introduction of improved mechanics and short exposures.*

"The clinical significance of radiography rose to a high plane when the success of *momentary* exposures, yielding pictures of the thoracic organs practically at *rest*, was demonstrated in 1899. With the increased sharpness and clear definition of the respiratory structures on the plate many advantages were gained. Beyond its actual diagnostic value it possesses also the advantage of economy of time and permits the satisfactory exposure of persons dangerously ill or too weak to endure a long seance.

"The correct relation of the parts of the thorax is best shown by a radiograph taken by the 'momentary method' with the patient *standing*. The standing posture is generally preferable to recumbency, though both positions have their uses. In fluoroscope work the erect position of the patient is practically always the best.

"The fluoroscope gives the correct view of the position, size, and quality of the organs, and alone shows the phenomena of *movement*, as, the pulsation of a tumor, succussion of fluid in the pleural cavity or in the stomach, the action of the heart, the excursion of the diaphragm, the respiratory movements, etc. But if a means of measuring and comparing is required the radiograph is alone the stable, sharp, and definite diagnostic picture. It has become part and parcel of the patient's history in the clinical record of a case, and is often a document of high value.

"Experience also shows that a true picture of the internal organs affords a diagnosis in some cases sooner than other methods of examining, and that the diagnosis is made possible *only by the radiograph*. While the divergence of rays coming from a single point shadows the inner organs larger than they really are, we do not require the absolute size in diagnosis, but only the relative size and position of the parts. If we wish to ascertain the exact size of a particular part, as the heart, we direct the examination to that end in a different way.

"As the degree of enlargement is in ratio to the nearness of the tube to the part, or the distance of the part from the film, we should make all comparative examinations at different periods at a standard distance of the tube and with the part as close to the plate as possible. Our standard distance is twenty inches betweeen the anode and the film. Only when this condition is fulfilled can pictures be compared with each other.

"In diagnosing the growth of the heart or of an aneurism or tumor, etc., these conditions are of serious consequence. The plate must in each case have the same relation to the wall of the thorax. Also there must be the same position of the diaphragm and the other structures of the thorax as represented by a given phase of respiration, as pictures taken without exact observation of these data lose their measure of value.

"Either deepest *in*spiration or deepest *ex*piration is exceedingly important in radiography of the thorax. *We generally choose the arrest at deep inspiration.* Have the patient practice precision in attaining and holding this position before the exposure. The beauty and sharpness of the outlines gain greatly by this position of the parts *with the ribs spread, the ribs and scapulæ elevated by extending the arms at right angles to the body, the lungs rendered most transparent with air, and the muscles and diaphragm resting.*

"The apex of the heart at the same time rises in a triangular shape and is seen very sharply on the flat part of the left diaphragmatic arch. Alterations in the free mobility of the diaphragm, partial fixation from pleural adhesions, small exudations, and other abnormalities can then be best defined.

"We choose generally the position of deep inspiration with the patient standing erect for our instantaneous pictures of the thorax.

"The branching of the bronchial tubes, thickening of the lungs, tubercle, etc., cavities, etc., are seen sharpest by this 'momentary' method. These are its great advantages, and when 'time' exposures are not indicated for diagnostic reasons *it is the method of choice of those who practise it.*

"On the other hand time-exposures *without* intensifying screen are preferable on denser parts of the body and in diseases of the bones, as caries, arthritis, tubercular disease, etc., when definition of minutiæ is required and the parts are normally at rest.

"Among the interesting observations of thorax pictures taken by the momentary method is the fact of the unequal heights of the two arches of the diaphragm. The popular idea that the diaphragm had two equal halves which moved alike in respiration is shown to be false. In both sexes and in all ages the right arch of the diaphragm usually rises higher than the left in health. There is often only a very small difference, but it is nearly always present in some degree and is visible in different respiratory phases, an interesting fact developed by exact radiography. The deep plane of the left arch falls more decidedly lower in cases of great hypertrophy of the heart. Hypertrophy of the left heart shows the apex beat in the sixth intercostal space. The fluoroscopic 'size' of the heart apart from age, sex, and size of the body, depends on the respiratory phase, and *to secure the best view place the patient in the position of deep inspiration.*

"Then the examiner can see, with a well-defining tube, changes in the lungs, pleura, and the diaphragm, and organs of the mediastinum, which are especially difficult to make out by auscultation and percussion. The retraction of the borders of the lungs from over the heart exposing its body plainest, the one-sided slope of the diaphragm caused by adhesion, tumors of the mediastinum, commencing pulmonary deposits, etc., can then best be made out.

"For general diagnostic information and analysis of *functional movements* the fluoroscope holds first place. But when detailed study of *pathological change* is required the radiograph is essential. If the first exposure fails to satisfy, make another.

"The difference between an acquired and congenital dextro-cardia can be seen at first sight with the fluoroscope. The more exact knowledge, difficult to otherwise diagnosticate, of the combination of cardiac hypertrophy with moderate pericardial and pleuritic exudation, is only gained with the radiograph; especially the question which arises so often as to whether the enlargement determined by percussion has its cause in hypertrophy only or is combined with pericardial exudation.

"*Pericardial effusions radiograph best when the patient lies in the abdominal position with the chest on the plate*, as then that part of the pericardium which lies against the front wall of the thorax is filled with the fluid.

"Especially instructive are pictures of the pneumo-thorax. By slight shaking of the body the wave-like movement of the fluid can be seen with the fluoroscope, rising and falling against the side walls.

"The kind and degree of displacement of the neighboring organs, the compression of the lung, the distension of old pleural adhesion, are easily demonstrated by the radiograph. All these pictures of marginal limits, of pleural adhesion, of transudations of the pleura, the degree of displacement, the irregularity of the borders of exudation at the period of resorption—the definite adhesions, are instructive for the student as well as for the physician.

"We are now much more careful with the fluoroscopic diagnosis of *aneurism* so long as it is of small extent, and belief in the decisive importance of pulsations as compared with mediastinal tumors is shaken.

"On the other hand, *the small half-globular elevation often seen in the left mediastinal space is not to be mistaken for aortic aneurism.* This prominence is probably caused *by the crooked position of the normal arch of the aorta* where it crosses the vertebræ. Post-mortems have shown that no aneurism existed in cases when this appearance has been noted, and further investigations will throw more light on the subject. If the radiograph and fluoroscopic examinations go hand in hand with other findings in the general examination for aneurism (when it is well developed) the diagnosis has no difficulty.

"The details of size, shape, and position of the aneurism against the mediastinum and heart, the displacement and flattening of the latter, would be shown by the radiograph, which should *always be made both dorsal and ventral.* The differentiation of a sub-sternal struma from an aneurism is easily shown by a radiograph on account of the irregular film structure of its lobes and of its chalky deposits, while aneurism has a regular diffuse shadow.

"The radiograph can be very valuable if there is a question of a differential diagnosis of bone and joint diseases, fungus, arthropathia tabica, arthritis deformans, hysterical joint neurosis, rachitis, osteomalacia, etc. The radiograph can give the diagnosis at once.

"In diseases of the lungs both the fluoroscope and the radiograph give valuable information. The parts of the lungs which are covered by the heart cannot be seen. This dark part of the lung belongs mostly to the left, though partly to the right, lung. *The apices of the lungs, as many negatives prove, are best seen in a vertical position of the patient.* We do not find that the clavicles are so great an obstacle as Levy-Dorn described. The fluoroscope shows both apices best if a *pliable screen* is used.

"To get a clear view the fluoroscope must be placed behind both supra-spinal regions, with a *slight backward bending* of the patient.

For the best front view of the apices a screen of triangular shape is used to show clearly the supra- and infra-clavicular regions.

"Abdominal diagnoses have not gained so much from the X-rays as the thorax, nevertheless valuable data are ascertained, and, as technic makes progress, results will improve. The size, shape, and position of the stomach, and the cardiac end of the œsophagus, can be shown by the aid of bismuth. The spleen and kidneys, *in persons with thin and delicate soft parts*, can be radiographed. The diagnosis of diaphragmatic hernia has been made after many fluoroscopic and radiographed experiments.

"By the injection of bismuth emulsion into the rectum the size and shape of the canal can be seen. Injections of gas distend the walls, cause increased transparency, and define a stricture."

CHAPTER XVI

DIAGNOSTIC OBSERVATIONS

The X-Ray and Coxalgia. Spina Bifida. The Brain. Arthritis. Thoracic Surgery. Solid Tumors. Subphrenic Abscess. Arterial Sclerosis. Carcinoma of the Œsophagus. Spoon in Œsophagus. Deviations of the Spine. Pott's Disease. Callus. Tarsus. Larynx. X-Ray Examinations of Children.

Among the many miscellaneous observations that have been made by different workers in fields of X-ray diagnosis we may well study a few which have been selected somewhat out of regular routine. A simple resumé of these phases of investigation will suggest hints for use when needed. It is not to be expected that absolutely every variation of X-ray showings can be presented in a formal survey, for to do so would fill a shelf with books; but examples such as are here cited are instructive and sufficient.

The X-Ray and Coxalgia.—In presenting a paper on Coxalgia, Coover remarks that, until the introduction of the X-ray, the early structural change undergone by the bones involved was largely a matter of surmise, although post-mortem examinations revealed a degree of absorption, necrosis, and local thickening, pelvic distortion, and inflammation of periosteal, ligamentous, and muscular tissues. Omitting the general considerations of his paper his note on the radiograph presented by him was as follows:

"On May 2, 1900, an X-ray photograph of the pelvis of the boy was taken at the Harrisburg City Hospital. Observe the great change in the left pelvic bones. The head of the femur is still in its socket, although the rim of the acetabulum is being absorbed and a degree of effusion exists. Careful measurements of the original photograph show considerable inequality between the two sides as regards the pelvic rim, the ischii and obturator forameni, and the trochanters major. The radiograph was taken with the face of patient nearest the photographic dry plate. A second one, taken six months after treatment begun, showed no effusion and some degree of improvement in the contour of the bony tissues, particularly the trochanter major and the acetabulum."

Josseraud has fully demonstrated the value of this method of diagnosis in the determination of the exact condition present in cases of coxalgia, and the beneficial influence which it has had upon the treatment in these cases. He has shown that the skiagraph will demonstrate the presence of osseous lesions and detect sequestra, making it possible to determine the exact condition of the bone and the situation of the lesion, so that if it is simply cartilaginous, or in the incipient stage, it can be treated by extension and rest, while the presence of any grave osseous lesion makes it possible to operate and remove the sequestrum or diseased area of bone before symptoms are present that would indicate it under other circumstances.

Spina Bifida.—The radiograph now shows with absolute distinctness whether or not there is an opening in the spinal column. It shows also the presence or absence of the nerve substance, and sometimes even its expansion in the sac. In those rare cases in which the presence of a lipoma or fibromyoma is in question the radiograph gives the needed information.

The Brain.—Regnier reported in 1900 his radiographic researches on the topographical relations of the brain, the frontal and maxillary sinuses, and the venous sinuses of the dura mater to the walls of the skull. His researches were undertaken to ascertain the relation of the brain to the skull, and to determine certain points in the anatomy of the skull and face. It was found possible to see the brain through the skull *in prepared subjects*, and thus to study the relation between the cerebral convolutions and the walls of the skull. Injections of liquefied substances which would become solid or which held metallic substances in suspension were made into the venous sinuses in order to study them.

The bony cavities, the walls, and the sinuses were best studied in dry preparations. The convolutions were best visible after the removal of the pia mater. The time of exposure of the radiographs made varied from ten to forty minutes. To anatomists wishing to repeat his experiments he advises that in selecting material for this work young subjects should be chosen, and arterial injections containing hardening materials should be repeatedly made. After about two weeks, the brain may be carefully removed from the skull, freed from its pia mater, and replaced.

In working out a diagnosis in a doubtful and difficult case, there is a lesson for all operators contained in the following report:

"We should never be satisfied with one radiograph of a case, but should make radiographs from different positions and compare also the picture of the injured part with the normal one. J. B., age thirty-nine years, sunstroke six years ago. Since that time a complaint of dull persistent headache on the left side of the head; altered disposition; was irritable, had vertigo, dyspepsia, vomiting, soon followed by slight palsies, but no convulsions. Lately retention of urine and symptoms more obscure. Muscles and mental state were unimpaired. Patient brought to me for X-ray examination.

"Twelve-inch spark coil was used, with Wehnelt interrupter. Tube ten inches from surface of head; plate behind the head; *photographic screen of tungstate of calcium placed over the dry plate to shorten the exposure.* Patient in elevated position with head low down. Exposure-time five seconds. With the parts of the head not examined covered with tin-foil, and those which were exposed shaved and oiled, I made six radiographs. The first one revealed nothing special, but the last one showed plainly a large epidural clot under the parietal bone at the sagittal suture on the left. The clot, amounting to four ounces, was removed, and recovery followed in three weeks without any complication." (Jicinsky.)

Few surgeons can point to a more satisfactory result of painstaking persistence in an X-ray examination than this.

Arthritis.—Radiographs distinctly show the absence or presence of enlargement of the articular ends of the bone in arthritis. The difference in the constitution of the joints in rheumatism, arthritis deformans, and gout is clearly shown. Cloudiness in the joints between the bones may be noted. In far-advanced cases of arthritis deformans the joints lose the clear transparent appearance and become dark in color.

The cartilages of joints are normally very permeable to X-rays, but if they atrophy on account of arthritic processes the radiograph often presents the appearance of ankylosis. The interspace normally found between the joint disappears, but the differentiation between diseased cartilage and ankylosis is easily made by the presence or absence of motion.

In Thoracic Surgery the X-rays have demonstrated that after subperiosteal resection of a rib, the exsected portion is always more or less re-formed. The extent of a thoracic pus-cavity can be shown by filling it with iodoform-glycerine. Subnitrate of bismuth gives a more marked shadow, but as it interferes with the treatment its use is not recommended for this particular purpose.

Solid Tumors, such as osteomas, osteo-chondromas, osteo-sarcomas, enchondromas, and fibromas, are successfully radiographed. In a case of aneurism of the thigh, with entire absence of pulsation, a surgeon was unable to identify the character of the tumor by the X-rays, but he excluded several possibilities for which the hard immovable growth could have been mistaken; viz.: osteoma, osteo-chondroma, and osteo-sarcoma. The aneurism gave no shadow, being covered by thick muscles, while tumors would have given a shadow. The structure and outline of the bone also show distinctly in aneurism.

Sub-Phrenic Abscess, the diagnosis of which was formerly so difficult, has become simple; the space between the diaphragm and the lower boundary line of the abscess showing distinctly. If situated between the diaphragm and the liver, the image is particularly distinct.

Sclerosis of the walls of the large arteries may be shown in nearly every part of the body by means of the X-rays, and the presence or the absence of deep arterio-sclerosis determined by positive or negative evidence. Aneurism of the carotid artery, the subclavian, the anonymate, and the abdominal aorta, have also been identified with the X-rays.

Carcinoma of the Œsophagus.—In attempting to make a differential diagnosis with the aid of X-rays between aortic-aneurism and intra-throracic tumor, Gebauer had the following experience. A pulsating tumor was seen and the pulsation was thought to be distinctly expansile. The diagnosis was made of an aortic aneurism. There was dulness under the sternum. Oliver's symptom was present, there was a systolic murmur, and the left vocal cord was paralyzed. There was, however, a marked difficulty in swallowing that was considered unusual for aneurism. The post-mortem showed a round pulsating carcinoma of the œsophagus, with a communicating abscess cavity, the mass being situated nine centimetres below the inter-arytenoid folds. The diverticulum formed in the wall of the œsophagus, had become adherent to the posterior wall of the aorta. This evidently explained the dysphagia and the expansile pulsation.

Spoon in Œsophagus.—In the case of a man suffering from melancholia Stembo made an X-ray examination and found a spoon in the œsophagus. It was twenty and a half centimetres long, four and one-tenth cm. wide, and the bowl was toward the stomach.

Diagnosis of Deviations of the Spine.—1. *Pott's disease.*—Redan and Loran report that a number of their radiographs clearly display vertebral tuberculous foci at different periods of development. Initial tuberculous lesions were revealed by radiographs of the vertebræ. In several cases the existence of the disease was thus discovered and treatment begun when the objective and subjective symptoms were too obscure for diagnosis. The radiograph also discloses, besides the number of vertebræ affected, the extent and depth of the tuberculous lesions, as well as the alterations in the neighboring tissues and organs. At an advanced stage of Pott's disease the negative indicates the extent of the lesions, the importance of the loss of substance, the existence of sequestrations and of tuberculous cavities, and the degree and cause of rachitic curvatures. Cold abscesses, particularly those treated by iodoform and oil, make a shadow on the plate. Negatives made at different periods will indicate the advance or decline of the tuberculosis process.

2. *Scoliosis.*—In scoliosis the X-rays disclose information which otherwise is usually only learned at the autopsy. One can see very clearly upon the negative the dorsal and lateral aspects, the various deformities of the body, pedicle, and arch of the vertebræ. Upon a number of plates taken by Redan may be noticed the bony union of several vertebræ and the existence of osseous products at the periphery, which teach us the stage of the case and the degree of rachitic rigidity, and consequently fix the prognosis and curability of old cases. It is demonstrated that the osseous tissue of the concave side is more dense, and the medullary spaces more close than on the convex side. Further, contrary to the usual opinion of former times, the osseous structure of the concave side, far from being atrophied, is the seat of a hypernutrition and of an osteo-genesis much more marked than upon the convexed side.

Callus.—The formation of callus may be studied by means of the X-rays. The quality of the callus and the development of density and opacity to the rays will vary with the age of the subject. In all X-ray examinations the trained observer must allow for age somewhat as the medical prescriber varies the dosage of certain drugs for adults, children, and infants. The difference in the proportion of animal matter (so readily transparent to X-rays) in the bone at different periods of life must be constantly taken into account in the interpretation of shadows. In some observations on callus, reported by a surgeon who does not state the age of the subject, there appeared after twelve days a slight shaded area at the ends of the bones which gradually became darker. In oblique fractures of the tibia the callus remained invisible for a longer time even after consolidation appeared to be complete. With a little care and some experimental work with bones and joints of young animals which may be obtained from the butcher's, and with some study of the shadows of cartilage between the joints of children of different ages, the interpretation of callus and a uniting fracture will be made with confidence. Early reports that the X-rays would show a fracture where none existed were undoubtedly based upon the untrained observations of men who had made no study of the shadows of cartilage and slowly consolidating callus. Early errors also arose from incorrect placing of the tube and the consequent passage of the rays in such a direction or slant that they failed to traverse the line of fracture. Obviously, if you do not look at an object you will not see it, and if X-rays do not " look at " the fracture they will not see it so as to report its existence.

Tarsus.—The chronic tumor-like swelling in the foot which interferes greatly with the walking powers of the soldier, and which arises from slight traumatisms, such as the sudden striking of the foot by the rifle butt, etc., has been looked upon as due to an inflammatory condition of the soft parts, as the tendons, joints, etc. The X-rays have shown that it is really caused by a fracture of one of the metatarsal bones, so that instead of applying massage and gymnastics, the foot is put up in plaster, and rapidly gets well with rest.

Larynx.—According to Freund the physiology of vocalization can be intimately studied by means of the X-rays. The alterations of the palate during the pronunciation of vowels, consonants, and various sounds in different tones have been watched with the fluoroscope.

X-Ray Examinations of Children.—A number of writers have emphasized the usefulness of the X-ray with children. With tissues easily penetrated, and small enough to bring very near the screen, a moderate radiance often enables the fluoroscope to reveal more in proportion than with adults. With non-noisy X-ray apparatus such as many operators employ, children are not alarmed, and may be examined without the removal of clothing, either recumbent on a canvas stretcher, or held by a nurse. Infants, indeed, sometimes go to sleep on the stretcher, and may be examined with the fluoroscope, or a radiograph taken, without disturbing them.

The thorax, abdomen, and head of children are all more accessible to this mode of examination than those of adults, on account of their diminished density and size. But the dosage of X-radiance must be reduced to the needs of the tissues. If rays are used of such penetration that the *borders* of the heart are rendered transparent, the shadow of the body of the heart will appear to be singularly *small.*

In some cases of pneumonia, especially the early stages, it is claimed that the presence of pneumonic areas may be determined by an X-ray examination when there are no physical signs. A writer cites a case—" A child of six years with high temperature, a leucocytosis (25,000), pain and stiffness in the back of the head and neck, the neck so rigid it could not be flexed. There was no history, and no physical signs were found in the chest after a careful examination by three other physicians who agreed on a diagnosis of cerebrospinal meningitis. In order to obtain further information if possible, an X-ray examination was made, and, finding a dark area over one lobe and a shortened excursion of the diaphragm on that side, the diagnosis of pneumonia was made without hesitation. This diagnosis was confirmed by a marked crisis and rapid clearing of the lung, as noted by later X-ray examinations. At no time during the course of disease could signs of consolidation be obtained by auscultation and percussion. In young patients with symptoms which suggest tubercular meningitis, it may be desirable to make a careful X-ray examination of the lungs, with a view to determining whether or not tuberculous foci exist there.

In pleurisy with effusion, or empyema, the X-rays may assist much in the diagnosis. Any condition of the lung which makes this organ less penetrable to the rays than normal, or limits the excursion of the diaphragm, may be easily observed. All the changes of the heart which in children are not readily detected by ordinary methods, are very definitely disclosed to the eye with the fluoroscope, and suitably adjusted X-rays.

The position and size of the spleen and liver are more readily observed in children than in adults. This is also true of the size and position of the kidneys, particularly the left kidney. By feeding the child bread and milk with subnitrate of bismuth, the size of the stomach may be determined, and the changes in size and shape after a meal may be followed. The changes in the size and shape of the stomach of a child during the process of digestion have thus been watched by Cannon and Williams. The advantages which young patients offer to this method of examination are sufficient to suggest that it be much more extensively employed by the profession.

CHAPTER XVII

THE ART OF READING X-RAY SHADOWS

Lessons in Interpretation. The Study of Shadow-Values. Definition and Contrast. Accessory Shadows as Aids to Diagnosis. How to Study Negatives and Prints. Directions for Beginners. X-Ray Atlases. The X-Ray Picture not a Silhouette.

The beginner will realize that *experience* is necessary in X-ray work; just as it is essential to the satisfactory handling of surgical tools, or the stethoscope, or the treatment of pelvic and rectal diseases, or the examination, diagnosis, and treatment of lesions of the eye. It is so simple a matter for any one to make a radiograph of a hand on the first attempt, that the experience required for valuable *diagnostic* radiography may be under-estimated. Tons of negatives and prints have been made as mere exhibits of X-ray shadows, without the slightest regard to the requirements of *diagnosis*. To raise the standard of his work the student should begin with the idea that every picture he makes must be made with an *object*—made to *accomplish something*—and not to simply add meaningless proof to the established fact that X-rays can impress an image on a film.

Not only take each picture in your early work with a definite determination to attain a definite result, but keep, compare, and study every failure and success with the plates side by side, and a record of the conditions under which they were taken. Not only compare the images on the plates, but keep in mind a mental picture of the part radiographed, and consider why in one case certain markings appear on the plate and in other pictures of similar parts quite different markings are obtained. The most rapid illuminator of the mind is a *quantity of experience, well-digested.*

Collect a considerable number of radiographs and study them, with a view to the basis of correct interpretation. In a month the man who does this will learn more and will possess a better critical judgment than others who may take a far larger number of pictures but who only glance casually at the "bones."

The language of an X-ray picture is intelligible only to those who speak it themselves. The knowledge of the language is attained by practice and experience, on the same principle that any other art is mastered. Behind the picture must be the trained understanding of what it *ought to represent*, and, therefore, a radiograph of the chest, eloquent to the pulmonary specialist, may be meaningless to the orthopædic surgeon; a picture instructive to the surgeon may mean little to a dentist, and neither the physician nor surgeon could well interpret the most beautiful work of the dental skiagrapher. The wonderfully scientific and remarkable ophthalmic work of a London surgeon, who has localized upward of 300 foreign particles in the eye during the past three years, would be as unhandy and as obscure in exact meaning to the general practitioner as would be the ophthalmoscope in the hands of a chiropodist. Therefore, each worker should grasp the idea that he must study radiography from the stand-point of what he himself *needs to show by it* in the class of cases which make up his particular practice. No one person will have time to become expert in every branch of electrical and X-ray technique and it suffices to attain reasonable skill *within the scope of your own work.*

These suggestions should direct the student wisely in concentrating his experience upon those uses of X-rays which will assist him with his own patients. After the foundation of skill is laid practice will naturally broaden the field of work. It remains, however, to say that while a correctly taken radiograph will be a truthful picture, yet it is not expected to tell the whole truth unaided, and when it has told all the truth it can we must be satisfied and supplement its story with other clinical evidence.

Various writers state that in order to lessen the chances of wrongly interpreting the appearances shown by a radiograph the operator should mark the point on the plate where a perpendicular drawn from the focus meets the film. With the author's "position finder" and circular landmark the diagnostic field on both plate and subject are automatically marked out. This delimitation of the diagnostic field centred in the axis of the rays is of primary importance. The radiograph has rendered great service in the diagnosis of fractures by revealing the number of fragments, their form, their position, their displacement in different directions, the location of splinters, etc.; but a special point for interpretation is the apparent overlapping of the ends of bones when this appearance occurs in the negative.

If there is an actual overlapping of one fragment upon the other and the exposure is made with the part at right angles to the central axis of the rays, the amount of overlapping in the picture will almost exactly correspond to the amount of shortening in the limb. If, however, there is no shortening and no *actual* overlapping, a right-angle view cannot produce the appearance of it in the picture, but it can be caused by posing of the tube and patient out of a right angle. If the rays pass through the upper fragment at an oblique angle instead of in a perpendicular line, they will project the shadow of the bone which is farthest from the plate beyond the shadow of the nearer fragment. This effect can be well studied by placing a small pair of scissors upon the back of the hand with the palm on the fluoroscope, and noting the "overlapping" caused by different departures from the central axis of the rays. The revelations of a moment of visual inspection will suffice to demonstrate this feature of the interpretation.

It is commonly said that for the purpose of gaining an accurate knowledge of the nature of a fracture it is necessary to take radiographs of it "at different angles," usually a front and side view. Those who write thus usually go on to say that "it is possible for a fracture to be unrecognized, even though it exists," and a strong point is made of this fact in references to medico-legal evidence. A few moments' study of a long bone in which you have made a half-dozen saw-cuts of various depths and directions will suffice to show that the vital point in the interpretation is not the taking of radiographs at different angles simply, but the centering of the break in the axis of the rays so that *the line of broken opacity will be traversed by the rays which act upon the film.* Put your eye at the side of a key-hole and attempt to see through the hole in the door. Unless the light from the other side of the door *reaches the eye in a straight line through the hole* your inspection will be negative. The study of radiographs with this principle in mind will interpret the shadows correctly if they were correctly made by a proper exposure, and if incorrectly made will interpret to a great extent the faulty position of the tube and the reasons for failure.

Crude and unskilled developing and treatment of the plate after the exposure is made will also interpret themselves to the trained eye of the observer who sufficiently studies the photographic technics of X-ray work.

On the other hand, it is often claimed that "the fluoroscope has not enabled the surgeon to detect a fracture." Some experimental study of fluoroscopy and its artistic refinements will easily interpret many failures. The secret of correct interpretation of a fracture with the fluoroscope is *clear definition* and correct alignment. Make a series of tests with any body of mixed densities and see how many variations of position, distance, and dosage of radiance will give negative results, and how exactly localized *is the narrow field of examination in which the view of the shadows will be correct.*

A screen which has deteriorated from lack of care, age, abuse, or was never of good quality, will not give clear definition. The finest fluoroscope procurable is the only one which should be used. The ordinary fluoroscopic examination as commonly made is so crude and unscientific in technique that it is superfluous to describe at length its long list of faults.

Briefly, it may be said that *correct interpretation with the fluoroscope requires the central fixation of the field, a right-angled relation of the plane of the screen to the axis of the rays, the closest possible approach of the part to the surface of the screen, and the regulation of the distance from the tube and the dosage of radiance to produce the degree of shadow-contrasts and accurate definition which is essential to the interpretation.* Follow this rule, and abandon haphazard manœuvrings with the fluoroscope at all sorts of distances and in all sorts of aimless directions, and accurate interpretation will follow, within the limitations of the instrument, *if the tube is efficient.*

The need of care in the interpretation of *marks on X-ray plates* is exemplified by the incident reported by Curtis to the New York Surgical Society. A child had swallowed a hat-pin two inches long with a glass head. The fluoroscope failed to detect it. An X-ray picture was made and apparently showed a thin dark body like the shaft of a pin in the œsophagus. This mark was afterward proved to be a defect in the gelatine coating of the plate—not a mere scratch on the surface which could have easily been recognized. The recovery of the pin in the stool proved that it was not lodged, and it may also be said that a more competent exposure with a fine tube would have made such a defect in the plate of little liability to deceive. Probably nine-tenths of the literature on X-ray fallacies should be understood as really but the growing period of skill before experience has taught the operator that a straight line will always be a straight line if he draws it straight. If drawn crookedly the fault is the operator's and not the line's. X-rays are straight lines, and nothing deflects them from a rectilinear path. In cases like the above "distortion" is not in question, but the error certainly was not of the rays.

The following item will interest many who seek explanations for some of their apparent failures in special cases:

"A blood-clot will often obscure a foreign body. In a case brought to me for a radiograph of the hand to locate a needle I did not remove the bandage. The doctor assured me that there were no pins in the bandage, but said that he had made several incisions where the needle was supposed to be. I made an exposure and found no needle, but found light, irregular lines which examination proved to conform to the incisions which were filled with clotted blood. Another exposure was made, and the developed negative showed the broken needle but no outlines of the clots. The needle was under the clot of one of the incisions and appeared on the plate after the clot was washed away.

"In another case while trying to locate a piece of steel in the eye I made an exposure with the plate on the side of the head and the tube opposite, but in the negative could not get the outline of the cavity of the orbit as is usual. I concluded that the reason for failure was a clot of blood. This was proved to be correct, as the eye was afterward removed and found filled with clot. The piece of steel was in the clot."

The Study of Shadow-Values.—The foundation training of the eye for the clinical interpretation of skiagraphs lies in the study of *shadow-values*. These values are relative and comparative. No part of the picture can be studied out of its environment. An isolated shadow may have no value. Nor do given densities of tissue create given degrees of opacity which can be valued out of their place. But just as we must know parts of speech before sentences can be construed, so we can study separate shadows to prepare the eye to read the entire picture.

Get together a dozen small blocks of wood, soft and hard, and varying in thickness from one-fourth inch to two inches; a few books of various thicknesses; some small and larger glass and wooden bottles; several sheets of tin-foil; a foot of sheet-lead; and at the butchers procure assorted bones and joints of various sizes, both of lamb, veal, beef, and fowl. Let some of them have the meat still on them. Add a variety of metallic trinkets and begin with the fluoroscope.

Take a single article at a time and observe its shadow—outline, margin, density, and definition—as these appear at different distances from the tube, and at different degrees of removal from close contact with the fluorescent screen.

Then partly *overlap* two articles and study the relative density of the single and double shadow. Increase and decrease in turn the penetration of the rays and note the effects of altering the position of the screen and the angle of the articles examined.

Twist and turn the bones and test the alteration of shadow caused by movements of the joints and different relations of the joints.

Observe metallic objects held on the proximal, and next, on the distal side of bones of different thicknesses. Also between two bones.

Also buried in soft parts. Note that the space between the metal and the screen affects the shadow in a typical way which tells its own story to the expert in his subsequent examinations in practice. Study all the possible effects with solid bodies, and then repeat them with liquids.

Partly fill the bottles with water. Study the shadow of different quantities of this fluid. Shake the bottle and note the visible waves. Wooden bottles will give about the same shadow as the same thickness of flesh, and they afford an excellent means of study. After noting the effects of water compare the shadows of blood, sputum, pus, etc. Particularly study how to manage the activity of the tube and your distance from the anode to secure the best shadow of such translucent substances as these last, especially when they are in small quantities. Much of the value of an X-ray examination of the chest will be lost unless the operator first acquires the art of securing the shadow that he wants to observe.

During these studies aim constantly at the maximum *definition* of each shadow before passing to the next. Study to develop the greatest contrast between two overlapping shadows, and do not consider the technic correct till it is adjusted so as to bring out all possible details. The importance of this early practice will appear later on.

In making these tests also note the effect on your powers of observation by a continuous hour's work in a completely darkened room. Hold the flame of an alcohol-lamp in the sunlight and you can see little of it; look at it in the dark and it shows fine contrast. That is the way with X-ray shadows. With an open screen they cannot be seen at all in daylight; with the closed fluoroscope they can be seen in a lighted room, but till the eye has had time to alter its sensitive mechanism the dimmest shadows will be lost. This may make no difference in a gross examination, but in fine work, such as the early diagnosis of tubercle, attention to this detail is necessary.

Develop these studies till practice gives confidence. Then practice similar observations on selected persons in ordinary health but of different ages and different muscular and bony mass. Learn the important fact that *each examination of a patient must individualize the technic and the findings*, for no two cases present exactly the same densities and relations to the screen or plate. Study of normal appearances is essential, just as study of normal histology is essential to the pathologist.

Then repeat some of these same tests with small plates. Develop the shadows that different substances can be made to cast on the negative by different " doses " of rays. Aim at contrast and clear definition. Learn how to avoid losing a faint shadow by over-exposure. Radiograph small masses of blood, serous and purulent sputum, sections of liver, heart, and other soft parts, fluids and various salts, metals, bones, etc. Make the pictures at different distances from the tube, and also study the effects of oblique variations from the central *axis* of the rays. A few dozen small plates used in this way will instruct much.

Definition and Contrast.—When the beginner has crossed the Rubicon, when he reaches the point of securing an apparent abundance of light, and sees no further obstacle in the way of his doing all that he reads has been done with the X-rays, the most important improvement needed in his work will be found to be the careful study of *definition.* The novice at first overlooks this factor in his joy at obtaining a bright radiance, but the expert looks more to definition than to mere quantity of light. The study is full of interest.

Light up a tube. Dash into it pell-mell a spluttering excess of exciting current and then look at a heart through the fluoroscope. The hazy shadow merely flickering on the screen gives you no idea of the true heart and its size or outline. There is no diagnostic value to the examination. But now with more care adjust the current to the indications of the tube, control the dosage to suit the capacity of the vacuum, smooth the interrupter to a sharp and even action, and then look at the same heart. In a favorable subject the heart can be seen as clearly outlined as a pear in front of the eye.

Look at the last joint of a single finger. Is it blurred or clear and sharp? Scan the bones of the wrist. Do the shadows merge and poorly define the articulations? Study at what position of the part, what distance from the tube, and what regulation of the current the separations are best seen. Look where the bones of the forearm, the muscles, the two shirts, cuffs, and coat-sleeve, make successive layers on the screen. If they appear in graded shadows, each distinct and plain, the proper definition of both tube and fluoroscope is demonstrated. But if not, then:

1. The fluoroscope, if an old one or not known to be up to standard, may be at fault, and its screen may be tested by comparison with another with the author's gauge.

2. The part under examination may not be in proper relation to the axis of the rays and at the best distance. Shift the part till the best effect is arrived at.

3. The quality and dosage of the current may not be regulated as needed. Try other adjustments till the tube works best.

4. *The focus of the tube may be defective.* This was common in 1896, and a simple test could often be made to show "astigmatism,"

and even at this date only the best tubes may be deemed well focussed. But too great a bombardment for the capacity of a tube will blur the focus and fog the definition. (Seventy-five per cent. of all the tubes entered for the gold-medal prize in 1901 failed in definition.)

5. If all these conditions are correct, and if a radiograph be taken and found lacking in sharp lines, the fault may be due to vibration of the tube if the holder or an unstable floor is stirred by heavy walking during the exposure. Movement of the patient is the cause of a blurred picture in many cases.

Having begun the study of *definition* compare your own prints with the best examples of others that you can procure till your judgment is trained. To comprehend much of what is meant by " poor definition " compare an ordinary *half-tone* of an X-ray picture with a really fine *print* of a similar picture. In the half-tone the details are not clearly defined, and, although a bullet or gross fracture shows its presence unmistakably in the reproduction, yet in many an able article published in the medical journals of the last four years and illustrated with half-tones authors have referred to so much that the reader could not trace in the pictures that it has been hard for a novice to acquit X-ray writers of imaginative exaggerations. Therefore, compare originals. Train the eye to recognize a lack of detail and learn to account for its cause in the technic. More practical knowledge can thus be gained in a few weeks of intelligent comparisons than unobserving operators will acquire in years.

Closely related in character and importance to sharp definition in an X-ray picture is marked *contrast* between the shadows of differing densities and different planes. First study by comparison of plates and prints the full significance of the word " contrast " in shadows, and then mentally digest the principle of procuring them. It is obvious that an excessively long over-exposure will reduce the contrasts by obliterating the lesser densities, while too short an exposure for a given purpose will not properly develop them. Therefore, after every other part of the technic has been mastered, the operator must seek contrast by a proper proportion between the degree of X-radiance and the length of the exposure.

The picture must not be made hap-hazard, but the *object for which the picture is to be made* must first be clearly in mind and the exposure-time carefully regulated to procure the kind of effect in contrast that is desired for the diagnosis. To secure sufficient contrast to show a bullet in the hip-joint would require only an exposure that would imprint the parts on the plate, but to show definition and contrasts in cases of impacted fracture, early disease of the bone, and certain other lesions, requires a predetermined position of the part on the plate, and a definite management of the dosage and exposure with the definite end in view. The mastery of these requirements denotes the expert.

But the novice who does not develop his own negatives will find a pitfall in certain photographic technicalities when they are not under his own control. A non-medical photographer, not knowing what the normal anatomy is or what object is sought in the picture, can heedlessly develop away a local shadow till it may be suspected to mean caries of the bone. A plate that is simply blank from sheer under-exposure may present a spot on the film that is taken for a gall-stone. These errors are totally different from the fallacies caused by distortion, and are avoidable by a study of fine contrasts. To instruct the reader in all that pertains to contrasts would lead us over the ground of several other chapters and be a useless repetition. If the importance and relation of contrast and definition in diagnostic radiography has been made clear by the above remarks we may consider that once started on the study the reader will never lose sight of it again in the increasing finish and refinement of his work.

Accessory Shadows as Aids to Diagnosis.—It is often desired to create an artificial shadow for the purpose of assisting diagnosis by better contrasts than the tissues afford. Pastes into which have been worked an excess of some metallic powder may be packed into a cavity, a cold abscess, the rectum, etc., and definition of outlines secured. A metal sound is sometimes skiagraphed in position to indicate direction or depth. A flexible spiral wire has been passed into the stomach in the lumen of a rubber tube in attempts to ascertain measurements, etc., with the X-ray. The gyromele may be similarly employed. A light roller-bandage with metallic bismuth-powder dusted in its meshes and bound around an arm, for instance, aids to bring out the contour in a stereoscopic radiograph. Charcoal, starch, and sugar, all create nearly the same shadow as would the equivalent of bone, and may be used in ways that will suggest themselves to special experimenters. Sulphur, lead ointment, and talcum are about as opaque as chalk, and as these are all available to the physician they offer a variety for the mixture of paste masses.

Benedict claims priority in the use of gelatin capsules containing reduced iron and also iron and bismuth. He first employed them February 9, 1897, "having had the matter in mind for some months." The idea occurred to many that if a capsule was filled with a somewhat opaque salt, say bismuth, its course down the alimentary canal after being swallowed could be observed with the X-ray. Any point of lodgment could be located, and various diagnostic suspicions could be thus confirmed. Two German writers early reported observations with tests made on fourteen patients with gastric affections and recommended the method as an excellent means of diagnosis.

But later others improved on the make-up of the capsule by substituting for its contents of powder a solid lead shot. Take a large gelatine capsule, put into it a shot as large as it will take, close the capsule, and cover the surface completely with a smooth layer of dental gutta-percha, applied warm to secure adhesion. This is easily swallowed, and is not acted on by the gastric juice. If the capsule is filled with as long and large a piece of "soft-solder" or fuse-wire as it will contain instead of a round shot the shadow may give increased evidence of the direction of the course pursued. In a communication on the diagnosis of intestinal obstruction a writer says:

"I have produced an artificial obstruction in the intestines of three dogs: one of strangulation, one by a twist, and one by a foreign body not opaque to X-rays. Each dog was given a lead capsule, and in all cases the exact condition could be made out in three hours after swallowing the shot. It could be seen with the fluoroscope during its passage, and could be traced gradually to the point of the obstruction in the intestine. It was not necessary to take a skiagraph. The diagnosis in each case was verified. I have swallowed a similar capsule myself to ascertain if it would pass freely without being affected by the digestive juices. It passed in two hours without any discomfort to me. I made a few skiagraphs in succession, tracing the pill in my own body, and it was very interesting."

On the other hand, intestines inflated with air become more transparent to the rays, and this fact has been utilized in some diagnostic procedures. Water also imparts another shading to the density of a hollow viscus. Those who need to experiment along these lines will be able to amplify the above suggestions in various ways.

Currie has made the following interesting "X-ray observations on hollow organs" illustrating the aid of accessory shadows in securing outlines of transparent parts. Due allowance must be made by the observer for the enlargement on the screen in proportion to the distance of the shadow-casting body. The instruction gained from reading this account can be applied to a variety of diagnostic uses.

"A piece of furnace-chain was drawn through a stomach-tube until the eye was reached. Thus the rubber, which is partially impermeable to X-rays, was reinforced by the metal chain, which was completely impermeable. The tube was then swallowed by a subject, and observations were made with the fluoroscope.

"Looking through the body transversely the chain could be seen very distinctly in the pharynx, and in the œsophagus to a point a little below the clavicle. As the rubber tube was pushed in or withdrawn, its point could easily be noted, and in the neck each link of the chain was very distinct.

"The Crookes tube was then lowered to the level of the stomach, and the subject turned so that he faced it. The stomach-tube and chain were then seen by placing the screen at the inferior angle of the left scapula. The individual links of the chain could not now be distinguished, but the shadow was distinct. On pushing the tube into the stomach its point could be seen to emerge from the right side of the shadow of the vertebræ. It then glided smoothly downward and forward, and ultimately the lower part of the tube rested upon the greater curvature of the stomach in an almost horizontal position. The tube rose and fell with each movement of the diaphragm. By means of a heavy piece of wire placed upon the skin of the abdomen the course of the tube could be marked upon the surface. The lowest point of the stomach was found to be two and a half inches below the tip of the ensiform cartilage.

"The experiment furnishes an accurate method of marking the lower border of the stomach. By gradually filling the stomach through the tube its surface marking could be determined for any degree of distension. The possibility of watching the tip of the tube as it glides along the surface of the stomach suggests a method of observing irregularities of the organ due to congenital conditions, constrictions, tumors within or without the organ, etc. The extent of movement of the tube furnishes a means of determining the extent of the rise and fall of the diaphragm under different conditions. The facility with which the chain and tube are observed in the pharynx and a large portion of the œsophagus, should prove useful. Dilatations of the œsophagus could be examined by noting the various directions in which the point of the tube could be made to travel.

"The course of the œsophagus is often altered by conditions such as aneurism, new growths, tubercular deposits, retro-pharyngeal, and retro-œsophageal abscesses, etc. These would not, as a rule, be shown by the X-rays, but by watching the alterations in the course of the chain, their location could be determined, and in some cases their extent could be ascertained.

"This experiment is but one application of a general principle. The rectum, colon, urethra, bladder, vagina, uterus, nose, and all cavities accessible from the outside could be examined in a similar way.

"A probe introduced into the nose can be clearly seen throughout the whole extent of the nasal cavities, as the surrounding bones are so thin that they are permeable by the X-rays. By means of the X-rays it would be possible, under the guidance of sight, to grasp with metal instruments impermeable foreign bodies placed deep in the nasal cavities; a similar manœuvre would be possible in many other cases.

"These experiments suggested that of introducing small bodies, impermeable by the X-rays, with the food of some animal for the purpose of observing the movements of the food in the œsophagus, stomach, and along the intestinal tract. The feasibility of this procedure was tested by placing a capsule, containing a few small shot, in the pharynx of a cat. The shot could be seen as they rapidly descended the œsophagus and entered the stomach. By turning the cat over, the shot could be examined from every side."

Still other suggestions have appeared along the same line. It is said that the size, shape, and position of the stomach may be made out in the following manner:

"Take a soft rubber stomach-tube with a small eye. Fill the lumen with small shot of a size which will not fall through the eye nor close the lumen. The tube must be well weighted, yet not too heavy for comfort. It must be freely flexible also. When ready for the fluoroscopic examination have the patient swallow the tube to any desired point, while you observe its descent with the X-rays. When it has reached the most dependent portion and its contour is seen on the screen take a pliable rod or coarse wire and bend it to the same shape. Place it on the skin over the stomach so as to register with the shadow of the swallowed tube, and then mark its line with a dermal pencil. If the empty stomach be now inflated by means of a rubber bulb attached to the outer end of the tube the organ will appear as a bag distended with air which is transparent to the rays, and its outlines can be noted distinctly and drawn on paper. Any operator requiring to make this experiment would need sufficient ingenuity to adapt the technics to the case in hand."

It has also been stated that in cases of children changes in size and shape of the stomach after a meal may easily be made out by feeding bismuth subnit., with bread and milk. For further technics see chapter on examinations of the stomach and abdomen.

Examining Negatives.—However acquainted the reader may be with writings and X-ray half-tones in medical journals, he cannot be a judge of correct interpretation of X-ray negatives *until he studies the negative itself with a knowledge of the part radiographed, and of every step of the technique which produced the picture,* from the state of the tube to the photographic development. If the beginner can secure the assistance of an expert friend to point out to him the different shadows of a good original negative, and explain to him why they occur, wherein they differ, and what they mean, it will profit more than a lifetime of looking at reduced, obscure, and blotchy half-tone illustrations. A man not familiar with anatomy will not at first either produce or interpret well a series of radiographs of fractures; but a mere photographic expert, who is not a surgeon and is not familiar with lesions, may produce a series of radiographs which look well, but he cannot well interpret them. Again, the expert clinician will overlook important evidences of disease in the first radiographs he examines, until the X-ray expert points them out to him and he acquires expertness himself.

When you look at a negative with the glass side toward the eye the image is reversed from the position in which the exposure was made, and is seen as it will appear in a print. If, for instance, the part exposed was a hand with the palm down, the appearance will be as if the examiner was looking directly at the palm.

If, however, we look at the negative with the film side facing the eye, it is as if the examiner stood in front of the tube and looked at the back of the hand. The simplest and an effective method of examining some negatives is to lay the plate with the film side down on a smooth sheet of glazed and heavy white paper, with a good light in front of it. The paper should lay on glass or a smooth table, and press closely against the surface of the film. Transmitted light is not used for this examination. Many details will be brought out which do not appear when the negative is simply held up in the hand and looked at in the ordinary way.

A good reading-glass which magnifies the image may aid much in examining the negative in this manner, and helps relieve the flat appearance.

Another method of examining negatives may be improvised by any surgeon. Simply make a pyramidal box-frame similar to a fluoroscope-frame with both ends open. Make the small end about large enough to fit over the eyes. Make the large end large enough to press against the negative just inside its edges. The frame will exclude all light. To study a negative, simply press it with one hand against the large end of the box, press the eyes into the small opening, and with a black cloth thrown over the head to still further shield the eyes look toward any good source of light such as a window on a bright day, or a lamp, or electric-light in the evening.

It is important to impress upon the beginner the advantage of studying X-ray negatives through the aid of *transmitted* light and with *darkness in front of the picture.* Those who have not witnessed the result can have no idea of the advantages thus obtained.

Those who have modern fluoroscopes from which the screen can be removed by unclasping the hooks have a ready-made dark-box as above described for examining the negative. Simply take out the screen, place the negative against the large end and hold it up toward the light. Look through the small end the same as in fluoroscopy. The view is one of the best that can be obtained.

A photographer's "retouching frame," large enough to take all but very big negatives, can be bought at supply stores for three or four dollars, and is a very superior means of examining X-ray plates. Simply face the light, lay the negative on the glass, shade the upper light with the top, and concentrate the light from below upward by means of the mirror.

In the examination of the negative study the following points:

How to best bring out all the details of the negative by both direct and transmitted light. There is considerable knack in holding the

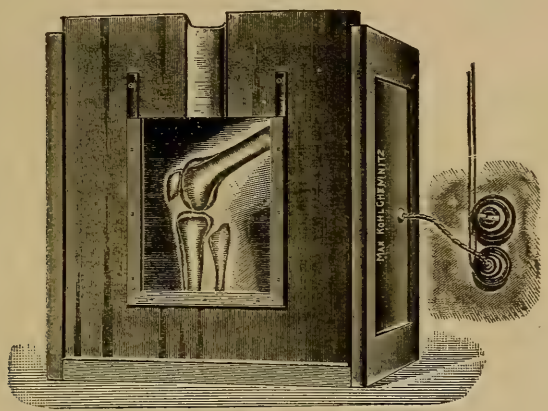


Fig. 14.—This figure very imperfectly shows a box for examining negatives with electric light inclosed behind the sliding front. The engraving is supposed to show a radiograph of the knee seen by transmitted light.

negative still, shifting its position, altering its relation to the light, and so on. Sometimes slight rapid movements will bring out shadows that do not appear otherwise. Study also:

How to know that you have a correct picture of a part.

How to read general shadows on the plate.

How to read overlapping shadows, and distinguish whether they are pathological, physiological, or due to slant of the rays.

How to translate special X-ray shadows into diagnosis.

How to distinguish between healthy and diseased structures.

How to distinguish between normal transparencies and the transparency of loss of substance.

How to collate knowledge of the case otherwise obtained so as to interpret the X-ray evidence correctly.

A *cradle-box* for the examination of negatives by transmitted light is one of the most pleasing adjuncts of the expert's outfit. Make a pine box sixteen inches deep and as large as your largest X-ray plate, say, 14 × 17. In this box install four sixteen candle-power electric-lights with an external rheostat to reduce or " dim " the light as desired. Face the box with a ground-glass front and swing it on a frame so that it can be rocked to any degree of a half-circle and fixed in the desired position with a set-screw. Out of plain black oilcloth now arrange four movable curtains which can be brought together in the centre from each side and from the top and bottom of the cradle. Use a free and long flexible cord from the lamps to the electric connection and the apparatus is complete.

In use lay the negative on the ground-glass face of the box and about in its centre. No matter how small a plate is to be examined the method is the same. Draw the four curtains up till they meet the edges of the plate and cut off all light except that which must pass through the negative. If the lower curtain is finished with a wooden bar which will fit in side slots of the frame the base of the plate can rest on this cross-bar very conveniently.

When the plate is in position turn on the lights and tilt the cradle to various test positions till it assumes the best relation to the operator's eye. Then vary the degree of light and study the shadows. Darken the room to a dim light.

To one who has never seen a fine plate with this advantage the effect is almost startling in its beauty. The plate is a " transparency " at its best. A dim light behind it will bring one set of shadows to greatest clearness; a brighter light will show forth still other effects. *No single-phase print, and no negative examined under ordinary conditions can approach the various and comprehensive effects brought out in the above manner.* The shifting of the cradle on an horizontal axis and the variability of the transmitted light reveals an X-ray picture in its highest diagnostic capabilities. It can be quite inexpensively made, and is a luxury to one who employs it.

Next, step back ten or fifteen feet and view the negative through a fine opera-glass giving high-grade definition, adjusted to an exact focus. The remarkable relief thus brought out is the nearest thing to a stereoscopic picture that I know of. It will be a revelation to those who judge X-ray work from prints or reproductions.

Examination of Radiographic Prints.—As looked at in the ordinary way these prints show to the least advantage. The aid of a large reading-glass will not only bring out the detail, but will somewhat improve the perspective. The picture will not look quite so flat. As a print shows a reversed position of the parts it will be helpful to the beginner to examine them with a mirror and good side light. Take several X-ray prints of different parts of the body and compare the direct view with the normal (and more satisfactory) appearance seen in the *mirror* with a proper light. When the operator has become expert he will be able to judge a print in any relation to the eye, but in cultivating skill in interpretation the mirror view is exceedingly useful. Try it. In case of doubt make two or more careful prints from the same negative, as faint details may be saved in one that are lost in another.

X-Ray Atlases.—To aid both beginners and others to more rapidly acquire experience in the diagnostic interpretation of radiographs a number of large atlases have been published. Earlier specimens were rather crude, but recent issues show much better work and suffer less in the process of reproduction. These plates can never represent the original negative in value, but the operator who can study his own negatives and learn to allow intelligently for changes wrought by each step from film to print, block, and book, will derive help in many of his less common cases by having a set of classical reproductions with explanations for comparison. To enable the reader to judge how much a surgeon not yet master of all that pertains to X-ray technic may learn from this source of current literature, to which monthly additions are being made, we cite here a selected notice showing the scope of one, and there are already a number of others:

"Atlas ———. This atlas, which consists of forty-eight plates, deals chiefly with infantile and orthopædic surgery. The plates are described briefly in the accompanying text, and each of the four divisions of which the book consists is prefaced by a more general account of the particular subject that is dealt with.

"The first fourteen plates are devoted to angular and lateral curvature of the spine, one being taken from the side. Some of them show remarkably well the good effect obtained in certain cases by forcible reduction of the deformity and subsequent fixation. The authors point out the very great value of X-rays in making an early diagnosis; in distinguishing caries from other affections of the spine and from neuralgia; in localizing the exact seat and extent of the disease; and in furnishing definite evidence of the influence of treatment in procuring consolidation of the diseased structures.

"The second portion of the work contains illustrations of rickets, exostoses, osteo-myelitis, osteo-sarcoma, genu-valgum, coxa vara, and deformities, such as club hand.

"Fourteen plates are devoted to tuberculous disease of joints, chiefly of the hip, and many of these show the peculiar translucency of the diaphysis, which, according to the authors, is one of the earliest signs of incipient osteo-arthritis. Softening of tuberculous foci is shown to be indicated by a diminution in the darkness of the central portion of the affected area, and by the much greater extent and clearness of the peripheral zone. It is pointed out that osteophytes (like callus) are very often translucent to the X-rays and in consequence are very lightly shown.

"Special attention is drawn to want of distinctness of the inter-articular space often seen in cases of joint disease, indicating, according to the authors, the presence of granulation-tissue growing from the bones or the synovial lining of the joint and filling up more or less of the interior.

"The last twelve plates are given up to congenital dislocation of the hip-joint. Several of them are taken from the same case, before and after reduction, and some of them are of particular interest as showing, not only that reduction can be effected in certain instances, but that it can be permanent."

In the best of the publications not only are the plates made from negatives selected as the most successful out of many, but efforts are being constantly made at great expense to secure improved processes of reproduction. Some have been devoted to special anatomical studies of the different parts of the body, while others aim to trace development and growth of bones from the fœtus to maturity. These works are destined to form in time an immense pictorial library for physiological, anatomical, and pathological reference, and, having done readers the service of stating their value, it is needless to here review them further. They teach nothing of technic nor of apparatus, but they aim to classify and interpret results.

The X-Ray Picture not a Silhouette.—Over and over again writers have called attention to the fact that an X-ray picture was "a silhouette only." Others have belittled its importance by stigmatizing it as a "mere shadow." Scores of writers have taken pains to explain that it is "not a photograph."

These remarks will not bear scrutiny. Take a piece of black paper and with scissors cut out the profile of a hand. Paste it on white paper. You then have a silhouette. Does it look like a *radiograph?* Hold your hand between a light and the wall. On the wall may be seen a mere silhouette of the hand, but is it equal to a radiograph? Now, take one of the finer negatives of some complex part of the body produced with superior apparatus by an expert. Examine it by transmitted light with a dark foreground. Even use an opera-glass or a good reading-glass as described before. Now note the difference between the product of the X-rays and the mere shadow on the wall and the silhouette. The contrast in its revelations and in its delineated detail is as great as that between a sheet of white paper and a printed bank-note. The radiograph reveals a series of superimposed and commingled shadows with lines and varying density. Depths are suggested to the trained eye, and contour is wonderfully seen in the stereoscopic X-ray picture. No photograph or product of the etcher's art shows more exquisite traceries and lights and shades than some of the best radiographs of bones. As a matter of fact, the high-water mark of modern radiography rivals as a picture and as an informing object-lesson the best of camera photography or engraving. The different purposes for which the radiograph is taken, and the unfamiliar nature of the information revealed by it, have led to the hasty conclusion that it is less of a picture than the familiar photograph. It is, in fact, among the highest type of pictures yet produced, and it has many years of development before it.

CHAPTER XVIII

AUTHOR'S X-RAY DIVERGENCE CHART

Directions for Uses in Scientific Radiography. A Study of X-Ray Divergence.

The explanatory description of this important aid to medico-legal accuracy in X-ray work is as follows: The Chart is a supplement to this course of instruction, fourteen inches wide and twenty inches long. It shows at a glance the following points of essential interest to the X-ray operator:

1. A plane diagram of X-light radiations from the anode focus point.
2. The rate of departure of X-rays from a parallel path at different distances from the tube.
3. The proportionate loss of right-angle shadows at different distances horizontal to the perpendicular axis.
4. The area of non-distorted field of observation at any distance from the tube.
5. The area within which a body of any thickness will shadow the right-angled relation of the part at a given distance from the tube.
6. The distance from the tube at which a part must be exposed to secure essential correctness and non-distortion for a diagnostic field of any given size.
7. The general area of *approximate* non-distortion on the plate.
8. The obliquity at all outside distances surrounding the central field of *exact* perpendicularity of radiation.

This Divergence Chart was designed by the author in November, 1900, and is now published for the first time. Its scale is limited for convenience to twenty inches as a working distance from the tube, and shows a maximum field at the base of fourteen inches diameter. Measurements of greater distances can easily be made by extending indicated lines.

The tube occupies a central position above a series of cross lines one inch apart which mark exposure-distances down to twenty inches from the Anode focus. The Cathode stream from the curved negative electrode impinges upon the platinum plate of the Anode, which is diagonally situated near the middle of the tube. From the impinging point of the cathode stream (the focus-point) X-rays radiate out in straight lines through a half-sphere of space. The straight red line coinciding with the plane of the Anode, and the red half-circle four inches from the origin of the rays, mark the extremes of radiation, but in actual work we select and use only a small field out of the full half-sphere. The working field may correctly be any part of the illuminated space, provided that the plate or screen *is at a right-angle with the radius of X-ray which meets its centre.* Otherwise the shadows will represent acute or obtuse angles and there will be distortion from this obliquity. For convenience the Chart illustrates a central field fourteen inches wide, or the greatest extent of a 11 × 14 photographic plate.

The *diverging red lines* illustrate a plane diagram of X-light radiations from the Anode point of origin, or focus point.

The *central* red line shows the path of right-angle ray which will carry a non-distorted shadow to the plate at any distance from the tube. With equal divergence on each side of this axis fine red lines show the increasing slant of the shadow from the centre to the edges of the plate.

The *black vertical lines* mark the rate of departure of X-rays from a parallel path, and the proportionate loss of right-angle shadow at different distances from the centre and from the tube.

These lines on each side of the centre (numbered from one to twelve) mark quarter-inches of deviation from the perpendicular. The outer lines (numbered from twelve to twenty) mark half-inches of X-ray divergence, and the distance within which any given degree of divergence occurs can be noted at sight by means of the black cross-lines which mark the distance from the tube.

Thus, a shot situated at the juncture of vertical line eight would appear on the plate half an inch to one side of its true location if the plate was five inches from the Anode and the shot was an inch above the film. With the same relation between the film and the shot, but removing the plate to twelve inches from the focus, the distortion is seen on the chart to be hardly one-fourth inch, while at twenty inches the shot shadow is less than one-eighth inch from the perpendicular. The same principle applies to the surgical relation of joints, fragments of bone, normal parts, and the correct shadowing of all foreign bodies.

But a photographic plate is *flat*, and the true boundary of the X-ray light which streams out in diverging lines like the radii of half a sphere is the circumference of a sphere drawn round the same centre. Any *arc* of a semicircle drawn at any distance from the focus will cut the rays at an *equal length*, but a *flat plate* does not. Rays of *equal length* in all parts of the field are the *sine qua non* of normal shadows on the plate, and with unequal cutting of a curved boundary by a flat plane only approximate exactness in shadows can be attained outside the focus centre. This is the insurmountable barrier in practical skiagraphy.

To illustrate the curvature of the surface required to be in equal focus in all its parts we have drawn upon each flat plate (as represented by each cross line) an *arc* which meets the bisection of the cross line and the axis. *At this bisecting point the plate is in perfect focus*, but the chart shows how limited a part of a flat plane can be in perfect right-angle relation to the cone of diverging rays. The series of arcs show the increase of this area at all distances from the tube up to twenty inches.

As the curve of the arc leaves the flat plane of the cross line which represents a photographic plate, the degree of separation shows the increasing deflection of the shadow of a body in proportion to its location above the plate.

At the outer extremities of the arcs the limits of the diagnostic field of *approximate surgical accuracy* are reached. The *Approximate Diagnostic Field* is therefore all that area on the negative plate indicated by the arc coinciding with the exposure-distance. The picture on the plate beyond the true diagnostic field is useful to show the general relation of the field to the whole part.

The limits of the *Exact Diagnostic Field* depend on the need of showing the exact relation of the parts and vary with the distance between the surfaces of the denser structures and the film, and the remoteness of the tube. Knowing, then, his case and his needs as to securing nearly exact right-angled shadows, the surgeon has but to note the distance on the chart that this field requires him to make the exposure. Or, if the exposure is made at the standard distance of twenty inches the chart indicates the *relative* accuracy of the picture within and beyond the *exact* field.

The *Exact Diagnostic Field* is the area between those two red lines equidistant from the equator which pursue a course through the essential thickness of the parts undergoing examination sufficiently parallel to the vertical black lines to shadow the parts on the plate in as correct relation with each other as the diagnosis requires. Its area will thus vary according to the distance from the tube and the thickness of the parts to be skiagraphed.

When diagnosis depends on contrasts of light and shade and densities of parts instead of the anatomical relation the field may be much wider, and a right-angled shadow is not indispensable as it is in the former case.

The more this chart is used by X-ray workers the more it will be appreciated. Knowing that his plate was correctly centred, and knowing the tube-distance from the film, the anatomist can demonstrate with the chart and the skiagraphed section of his subject the exact lines of divergence and the degree of accuracy represented in the picture, and thus give legal value to his evidence. This will do away with past complaints about distortion, and greatly increase the dependence on X-rays.

In future no surgeon will examine a case without the guidance of this standard chart even in private practice, and no case will be tried in court without its supporting proof of accuracy. When employed in conjunction with the author's "position finder" for centering the plate, and with my "landmark" included in the picture as evidence of the position, an X-ray shadow of a part can be interpreted with more confident certainty by anatomists. In other classes of cases, when the tube for special reasons is placed at an angle, the lines of the chart instantly convey to the eye the rectifying interpretation of the shadows and point to the section of the plate in actual relation to the object sought. In many ways the chart will serve the X-ray operator as experience discloses its utility.

It will be observed on the chart that the distance of the film from the source of rays increases with the departure of the *flat* plate from the *curve of the arc* of the radius. The *sides and ends of a plate* therefore receive a "shorter exposure" than the centre of the plate which is in the radial axis. This divergence of the rays is so great at close range that a large plate might be under-exposed ten, twenty, or even thirty per cent. at the corners while fully exposed in the centre. The old rule that a tube should be at least as far from the plate as the diagonal measurement of the plate is inadequate for exact work, while our chart shows at a glance the exact distance a plate must be to bring a required field within a required directness of radiation.

A Study of X-Ray Divergence.—From casual reading of X-ray literature the majority of surgeons are familiar with the word *divergence*, and the fact that X-rays are said to diverge thirteen-sixteenths of an inch in every sixteen inches of distance from the tube. But it is doubtful if many are clear in their understanding of what to do about this divergence, or what it may really signify in their own work. Let us try to clear the matter from confusion in the simplest way.

"Divergence" does two things. It causes the shadow of an object to appear larger than the real size of the object in proportion to its distance from the screen and tube; and it carries the shadow to the screen or plate in a slanting direction instead of down a straight line. To these two things are due what is called "distortion." If the rays were side by side (parallel) and had no slant they would go straight through a part and impress its image on the plate or screen without enlargement and with a normal position.

As a picture of parallel rays we may look at the vertical black lines on our chart and see that a bullet at the top or middle of any one of them would cast a shadow of the same size directly below it to a plate at any distance. The red lines diagram visible diverging rays to the eye, and though they do not represent all the X-rays they suffice to show that a body above the plate will cast not only an enlarged shadow, but a shadow that is displaced in a slanting direction so that it is not *under* the body, and the chart shows exactly how far any slanting ray will take a shadow out of a direct path. The chart is drawn in a single plane, but the rule holds good for all the lines of a cone.

What does it mean to "rectify distortions of position"? As X-ray pictures are shadows within shadows and not mere silhouettes, it "distorts" the relative relation of the parts if the shadows slant instead of the rays going straight through them. The only way to get the rays straight through a part so that every one of the combined shadows will bear the normal relation of life is to place the part in its long axis square with the axis of a central path of rays. If you want an "undistorted" shadow of your hand on the wall you hold it flat in the path of the light. Exactly the same principle applies to placing a part for examination in the path of X-rays so that "distortion" will be avoided. What is called an "accurate cross-section" of a body or limb is secured in this simple way. To "secure parallelism of the rays" is exactly the same thing in practice. All the writings which discuss these features of random X-ray work lead to the one simple fact that *a part ought to be placed with its long axis at right angles to the axis of rays which will pass through its centre in a straight line* instead of at a slant. It is no more trouble to do it than it is to do it a wrong way, and only requires grasping the idea and carrying it out in practice as a routine rule. There is absolutely nothing to prevent any surgeon from so placing the subject of his examination except the total lack of a desire to do it. As divergence is the cause of two things to be avoided in X-ray work —magnification and distortion—we will study the details of distortion more fully in the next chapter.

CHAPTER XIX

STUDIES IN DISTORTION

A Chapter Devoted to Clearing Away Fictitious Difficulties.

Lest the word *distortion* become a bugbear to the beginner in X-ray work, let us study for a moment exactly what it means, and its relation to examinations for diagnosis.

X-rays which have traversed the tissues of the body mark the photographic film with shadows which are carried down from the tissues to the recording film in perfectly straight lines, which radiate from a point exactly as the lines of sight radiate from *one eye*. Our Divergence Chart is a plane map of these diverging lines. Spread it upon a table before you, and assume that any one of the black cross lines which indicate inches of distance from the focus, is a photographic plate. Now lay a small bullet upon the perpendicular red line in the centre and observe that, no matter whether you move it one inch or two inches, or four inches, or any distance up or down from a plate which may be either ten, twelve, fifteen, eighteen, or twenty inches or more from the focus, the shadow of the bullet falls like a plumb line to the centre *directly below it*. No matter how far the shadow travels from the bullet to the plate, it will fall directly *under* the bullet, and an incision in the same line would find it straight below the knife in the tissues of the body. In this case "divergence" of the rays does not cause any deflection of the shadow in an oblique line, because the bullet is in the straight line of an *axis* between the focus point and the plate, and there is no divergence in its field.

Leaving the imaginary plate at the assumed distance, say sixteen inches from the focus, place the bullet on the axis at the fourteen-inch cross line, which will make it two inches above the film. Move it laterally along the cross line to either right or left of the equator. It moves parallel with the film, but when it is a half inch, an inch, an inch and a half, two inches, or three inches, etc., from the equator trace down each *slanting* red line from the point where the bullet rests to the plate two inches below. The shadow of the bullet will not fall directly down the *vertical* black lines, but will follow the *slant* of the red lines. When the bullet at fourteen inches from the focus is actually five inches to the left of the axis, or centre of the plate, its shadow will fall on the plate six inches to the left of the centre. This, therefore, would be a displacement of one inch from the vertical axis, under the given conditions of distance from the focus and distance from the plate.

The Chart will instantly show every possible variation from a perpendicular line for every fraction of an inch to the right or left of the equator, and for every fraction of an inch of vertical distance. *It shows at a glance what many writers have explained by elaborate algebraic and geometric calculations.*

Compare the side displacement of the shadow of the bullet in proportion to its nearness to the film, and observe that there is no deflection at all if it is in *contact* with the film. Compare the difference in the side displacement of the shadow of the bullet two inches away from the film, when the film is six inches from the focus, ten inches from the focus, and twenty inches from the focus. Observe that the proportionate divergence of the shadow from the right-angle line between the focus and the plate *is less at the greater distance from the anode*, though the bullet actually remains the same distance from the equator. This guides the operator to an accurate choice of distance in making exposures to secure for a given area of tissues the smallest amount of deviation from a straight line. This is called *the elimination of distortion.* We have seen that all distortion is *eliminated* in the central axis of the rays, and it is perfectly easy to make all examinations and all radiographs with the essential tissues falling in or near the axis of the rays, and thus practically dispose of distortion.*

But there is one other side to the study of alterations between the position of the shadow and the substance in X-ray work. See how the red pyramid widens from the point to the base. If a piece of metal three and a half inches wide was placed five inches from the anode, and photographed with the plate twenty inches from the anode, the shadow would be *magnified to fourteen inches in width.* If the plate was brought up to six inches from the focus (one inch below the sheet of lead) its shadow would be magnified to only four and a quarter inches wide, or three-quarters of an inch in excess of life size. If, however, the lead and the film are both kept only one inch apart as last stated, but are dropped down the path of the rays, till the plate is twenty inches from the focus, the chart shows that the shadow will be magnified *less than one-quarter of an inch larger than the actual size of the substance.*

* See directions for the Author's Examining Frame.

The Chart then shows that tissues of any given thickness containing denser substances at an approximated distance from the plate must be examined or radiographed not only with reference to the *central axis* of the rays, but with reference also to the *magnifying* effects of the radiations in the cone-shaped field around the axis.

Now let us have a short session in practical object lessons. Set up the author's examining frame on its standard with the marking rods and balls in random positions anywhere between the tube and the fluoroscope. Clamp the fluoroscope to the frame to free both hands, and, comfortably sitting on a stool, observe the shadows falling on the screen as you turn the frame slowly on its pivot and hinges. At different positions remove the eyes from the fluoroscope and compare the line of the bars and rods as they appear to one eye with their shadows as cast on the screen. The amount of travelling that a fixed ball or rod will appear to do when swung aside from the axis of the rays will teach the necessity of correct alignment when living tissues are examined.

Next change the frame with its vertical and horizontal rods for the author's X-ray gauge with its round window and square cross-bars. Set it up horizontal to the path of the rays and observe the shadow of the window through the screen while moving the base laterally from side to side and turning it on its own axis. Note the change of the round circumference of the window into a longer and longer ellipse, until, finally, it becomes little more than a narrow slit, as the gauge presents nearly edgewise to the focus. These studies of what is called the "distortion caused by position" of the object examined will be invaluable to teach the operator how to avoid it, because the moment the gauge is properly turned toward the rays so that they pass equally through it, the shadow of the ring resumes a normal circle.

Next hold the hand against the screen of the fluoroscope as if for an ordinary examination. Outside the second joint of the middle finger press the handle of a pair of small pocket-scissors. Make straight movements of the fluoroscope from side to side, and also tilt the screen obliquely up and down and turn it in various directions. Note how the shadow of the metal can be made to travel over to the index finger, which the scissors do not touch at all, or over to the little finger, or up the carpus, and down to the last phalanges, without in any way altering the actual position of the scissors upon the joint of the middle finger. This illustrates deflection of objects *out of alignment* and their exposure to slanting rays. It also shows *how to avoid this needless kind of distortion.*

In various other ways, which will suggest themselves, the physician may study distortion with specimens of bones, joints, and anatomical preparations. It is invaluable study. The philosophy of it all is, that in practical work the knowledge thus gained will enable the operator to interpret conditions in which some distortion is represented, to recognize unnecessary distortion when it occurs, and to so adjust the distance of the tube, the axis of the rays, and the distance of the part from the screen or film, that his own work will contain few of the "fallacies" that he reads about. The main thing is simply correct *alignment.*

The so-called "distortion" by X-rays is a radically different matter from the actually distorted image seen when we look into a concave or convex mirror. Aside from the special factor of *penetration* X-rays image the contour of a bone *according to the angle at which it is held,* precisely as does the normal sight of *one eye.* If the eye and the focus of the X-rays have the same alignment with the object viewed they will both exhibit the same results as to contour. If we sight a long bone transversely, or obliquely, or longitudinally, with one eye at twenty inches distance, we *see its contour in its different positions in the visual axis in precisely the same shape that the X-rays will image the shape on the plate.*

Yet when we look at a bone with an eye and hold the bone in different axes to the plane of sight we do not think our sight *distorts the bone.* We recognize that we only see a true contour of the object according to the position in which we hold it with reference to sight, and "fallacies" of the vision are not spoken of as if sight was intrinsically deceptive, distorted, and unreliable, dangerous to consider evidence in diagnosis, and something to "await improvements in" before we used it.

Nor is it a "fallacy" of either normal vision or the X-ray if we hold the bone we seek to examine *so far to one side of the line of sight* that we cannot see it clearly without turning the eye or the Crookes tube into better focus. The same laws of divergence and alignment of the lines of sight apply to the image on the single retina and the image on the screen and film. The difference in the visual quality of the two processes is great, but the mechanics of divergence, distortion, and enlargement are the same in both cases. It is well to bear this common-sense fact in mind when reading some alarming account of X-ray perfidy. You will not see the long axis of an object with either the eye or the X-ray if you hold only its short axis in front of you, and as X-rays cast shadows only by transmitted light, we must hold the object so that the axis we want to observe will cross

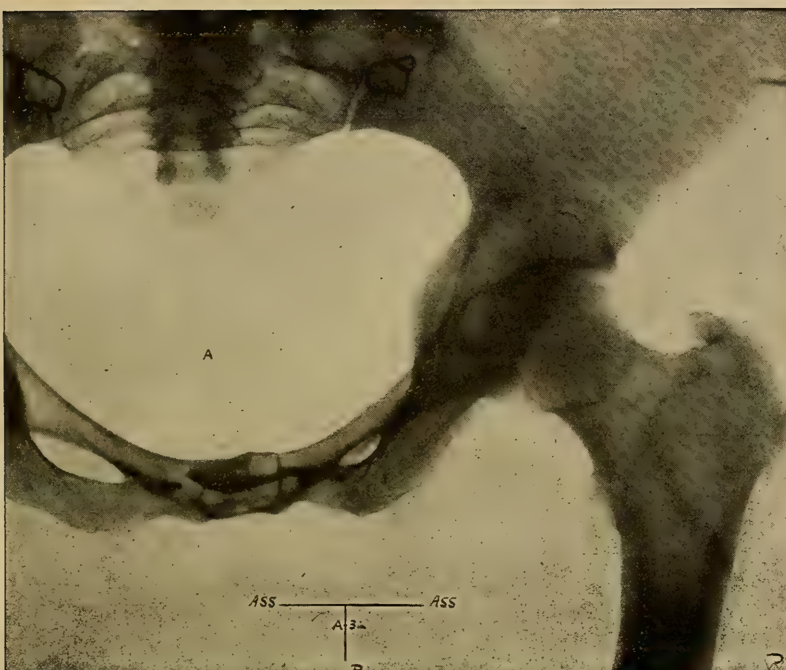


PLATE 41.—Plate One of Williams' Series of Hip Exposures. The series of four reduced hip-joints which now follows illustrate a normal and single hip and show, not the wild distortion of X-rays, but the need of the accurate placing of the anode over the exact part which the diagnosis requires shall be in the axis of the rays. The tube in all four pictures was 18 inches from the film. In this exposure the focus was over the letter A. This would do well for the pelvic basin, but not for the neck of the femur. See full description by Dr. Williams, of London, in this chapter. (Rebman, Ltd.)

PLATE 42.—Plate Two of Williams' Series of Hip Exposures. The tube was three inches above the level of the anterior superior spines in the mid-line. The result shows less neck than in the first exposure of the same part, and the angle of the neck, and shaft is greater than normal. See text for full description.

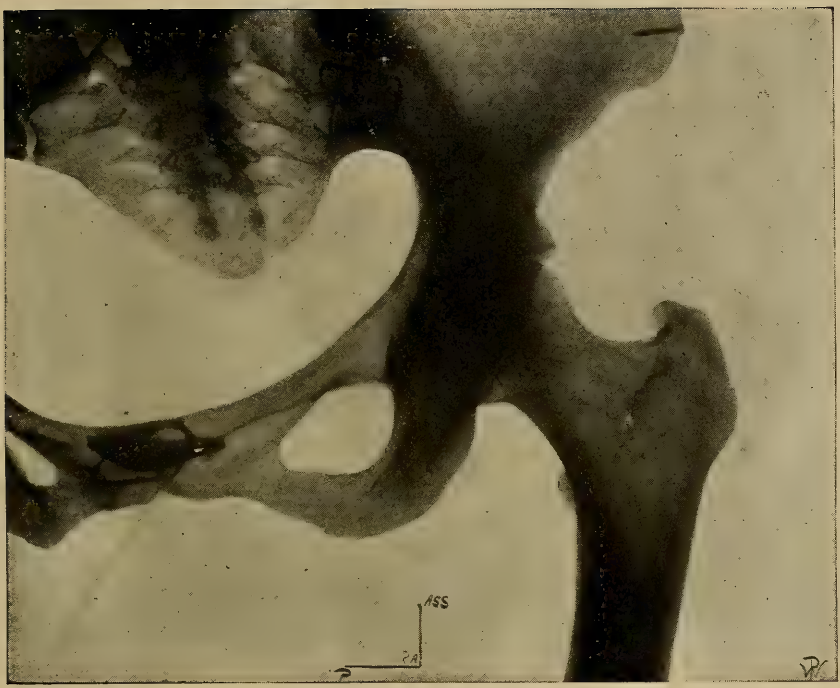


PLATE 43.—Plate Three of Williams' Series of Hip Exposures. The inner sides of the feet were placed together and the anode over the letter A directly on the centre of the union of shaft and neck. The result is therefore a normal neck with the proper angle. But this posture throws the shadow of the basin out of true, and again illustrates the fact that the axis of the rays can be in but one place at a time in a radiograph. It must be placed where the requirements of diagnosis demand it and not simply at random over a general part.

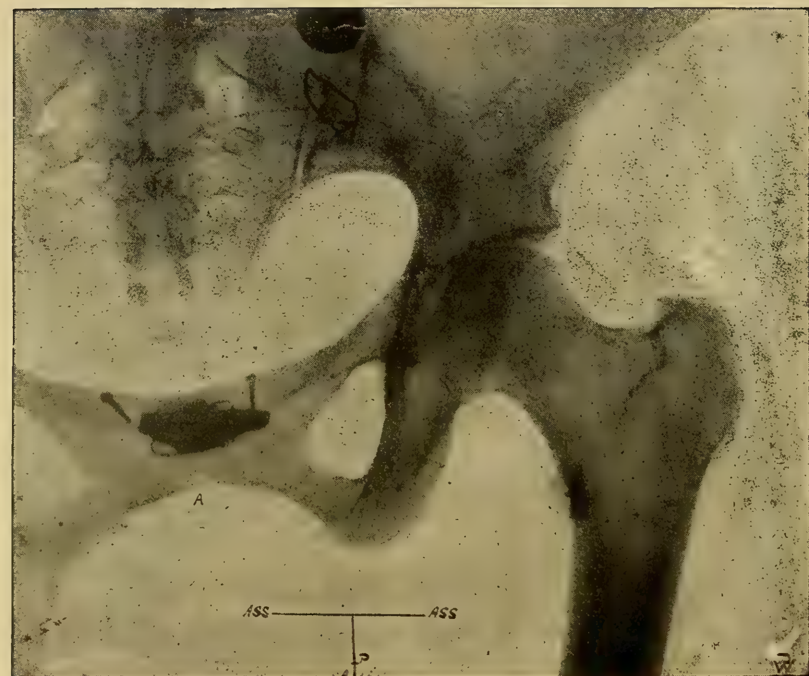


PLATE 44.—Plate Four of Williams' Series of Hip Exposures. The letter A shows where the anode focussed for this radiograph of the same hip. Were it not that the bone was rotated inward by placing the feet together, the greater tuberosity and head would be practically producing a false appearance, as of the condition termed "coxa vara." This does not exhibit the "inaccuracy" of X-rays, but only the need of focussing the vertical axis on the direct field of diagnosis instead of taking the essential part of the picture by slanting light that carries the shadow out of line. The operator controls the accuracy of his results. Study this chapter on distortion and it will be easy to avoid distortion.

the line of transmission. The obvious simplicity of the principle commends it greatly to surgical use.

A valuable article was recently presented by Williams, of London, and from it we may read with profit the following extracts, referring at the same time to Plates No. 41, 42, 43, and 44.

"At the Congress of the German Society of Surgery, in 1898, ——— showed a number of skiagraphs of the same normal adult pelvis from various points of view, which gave false appearance of deformity of the pelvis and femurs, produced by the tube being placed at several points above the subject, and by altering the distance between the tube and the sensitive plate. The majority were very much exaggerated, and such results would now be produced only by an exceptionally ignorant or careless operator. I have here four skiagraphs of the adult hip-joint. In each the tube was eighteen inches from the film, and the position of the anode was such as might be used by any ordinary operator with reasonable care.

"In No. 1 the tube was placed in what is probably the most common position; namely in the middle line between the hip-joints and three inches in front of a line joining the interior superior spines, with the heels on the table and the toes rolled outward. You will notice that the shadow of the head is thrown outward and slightly downward on to the neck, shortening that part; the more the toes rotate outward the more the greater tuberosity obliterates the neck, and if the rotation was about thirty degrees the neck would entirely disappear; the angle of the neck with the shaft is less than normal.

"In the next one, No. 2, the tube is placed three inches above the level of the anterior superior spines and in the mid-line. Here even less neck than before is seen, and the angle of the neck and shaft is greater than normal. The farther up the abdomen the tube is placed the more the head will join the shaft, and so all trace of the neck can be obliterated. Also the outer edge of the greater tuberosity will be projected outward and downward. In this picture the angle between the neck and the shaft is much greater than normal. In No. 3 the inner sides of the feet are placed together, and the tube was fixed over the angle made by a line about parallel with the middle line of the body drawn from the anterior superior spine, and another at right angles to this to the pubes. This places the tube right over the neck and gives the very least distortion; the angle of the neck with the shaft is normal, that is, 128 degrees. The obturator foramen in this view is nearly circular; in all the others it is more oval or even triangular. The mid-line of the sacrum is directed toward this foramen, and the shadows of the coccyx would nearly impinge on the brim of the pelvis.

"In the next picture, No. 4, the tube was placed one inch in front of the pubes in mid-line. Notice that the angle of the neck and shaft is more acute, and, were it not that the bone was rotated inward by the feet being together, the greater tuberosity and head would be practically producing a false appearance as of the condition termed "Coxa Vara," wherein the neck is practically at a right angle or less with the shaft.

"It is an interesting point to note that in young children the Y ligament which lies across the socket of the hip-joint shows in a skiagraph as a light space, it being cartilage, and, of course, more transparent to the rays, and normally the upper margin of the head should be opposite that point.

"Examples of skiagraphs failing to show what was expected are familiar to all. A distinguished surgeon read a paper before a clinical society upon congenital dislocation of hips, and had three skiagraphs, one of which I happened to see while he was reading his paper. The tube had been placed low down the thighs, and, therefore, projected the shadow of the neck upward. I spoke to him hurriedly, and that picture was not handed around. Another skiagraph was taken next day with the tube in proper position, when the hip-joints were found to be normal."

CHAPTER XX

THE AUTHOR'S X-RAY PENETRATION GAUGE

A Standard Measure of X-Radiance. Recording X-Ray Intensities. Standardization of the Gauge. Penetration Register. "Radiometers."

This practical instrument substitutes for the unequal eye and doubtful judgment of different operators a mechanical measure of X-ray penetration, in both photographic and fluoroscopic capacity. It settles several disputed points. It affords a definite method of testing fluorescing screens and Crookes tubes, and of standardizing the degree of X-light at required efficiencies. It makes possible a uniformity of results in X-ray negatives by determining the relation between exposure-time and the state of the tube. By its measurement and record, a surgeon in London can reproduce a particular degree of X-radiance reported in New York, and with perfect exactness can adjust his tube to the same efficiency and duplicate the same work. It completes the solution of the problems of standard light, standard postures, and standard time of exposure, to secure standard results on the negative. With equal photographic treatment during developing processes, the interpretation of X-ray shadows may now start from a more definite basis.

Of the many pocket devices called radiometers, photometers, etc., all that I have formerly seen cover but a small part of a large fluorescing screen, and allow the eye to fill with light from the surrounding field. They are pocket toys without scientific value. My own instrument is an altogether original and different thing. It is constructed as follows: A plate of lead is sandwiched between two plates of brass, making a solid metal base six-sixteenths of an inch thick. This base is made larger than the screen of the given fluoroscope, so as to shut out all rays except those passing through the window. In the centre of the base is cut a round window three inches in diameter.

Four wires next make cross-bars at right angles within the window. External to the window are twenty shutters of twenty-eight gauge sheet-brass stamped and numbered. The set of shutters is swung on a pivot, so that one at a time can be cut out from interference with the rays, or inserted as desired. Each shutter is four inches square, and a set screw on the pivot permits shifting them to suit. The lower side of the base is finished with a ledge at right angles on which to rest the frame of the fluoroscope. A pair of clamps at the top hold the screen or fluoroscope in position, thus leaving both hands of the operator free. By a heavy flange underneath the ledge the entire instrument is fitted to a telescoping brass standard, which can be raised or lowered to the level of the operator's eye for sitting or standing observations. A second post at one corner of the shutters catches them as they are turned back from the window.

To use the instrument clamp it on the standard, place it in the path of the rays, at the desired distance from the tube, and start the tube into action. Tests can then cover the following nine points:

1. The comparative efficiency of different tubes.

2. The comparative efficiency of different exciting currents from different apparatus with a given tube.

3. The comparative efficiency of different "doses" of current from any one apparatus with any tube.

4. The maximum (or any) radiance of any tube with a given current.

5. The *defining penetration* of any degree of X-light for record or reproduction.

6. The standardization of exposure-time for standard distances with given densities and thickness.

7. The law of inverse squares as not related to X-radiance.

8. The quality of any new or old fluoroscope of any make or material.

9. The relation of photographic activity and fluoroscopic efficiency to a given degree of X-radiance and to each other.

To test the quality of a new fluoroscope or to detect possible deterioration in an old screen, set up the gauge six inches from the tube. Then operate the tube with a small currrent, and only generate enough light to barely outline the ring of the window through two shutters. If the radiance of the tube used is not easily reduced to the exact point increase the distance between the tube and the gauge until the shadow of the ring is at its faintest visible outline. Make this test and all others requiring accuracy in an entirely darkened room. Keeping the tube and gauge in the same relation, compare now the definition of the window rim with each screen at hand, and it will plainly appear which fluoresces best. The percentage of difference

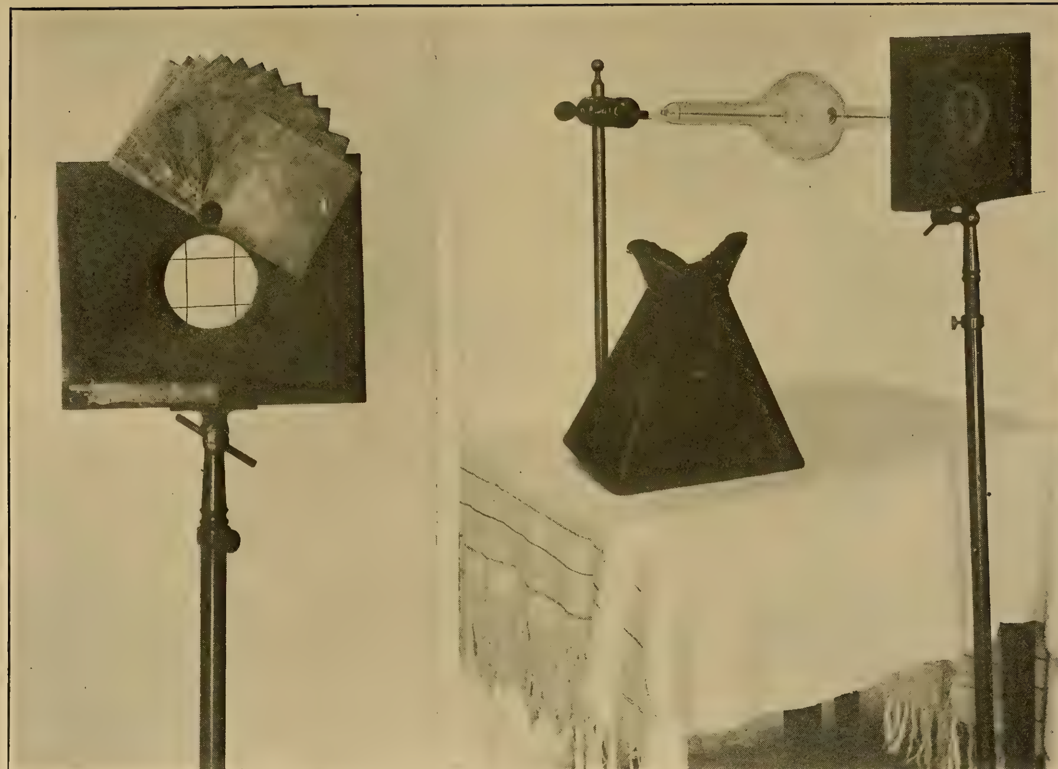


PLATE 45.—Author's X-Ray Gauge. Figure at left shows gauge set up on standard with shutters up and window with bars exposed. This side of the gauge faces the tube in use. On the right is seen the gauge in position for tests. Level the window with the focus at the desired distance from the anode, cover the window with the set of shutters, clamp the fluoroscope on the ledge of the base, and start the tube into action. Then make measurements as taught in our text. The gauge gives a definite record of both penetration and definition and is mathematically exact when employed under correct conditions for fine fluoroscopy. See text for full description.

PLATE 46.—Author's X-Ray Gauge. This plate shows manner of shifting the shutters, one at a time, with the right hand while observing the effect of any degree of radiance upon the window and bars of the testing field. The operator sits in a chair with gauge and tube levelled to suit convenience. This is the only adequate and simple " meter " of X-radiance yet devised. By aid of the text and Instruction Plates any one can use it as taught. It is one of the prime necessities of scientific work with X-rays.

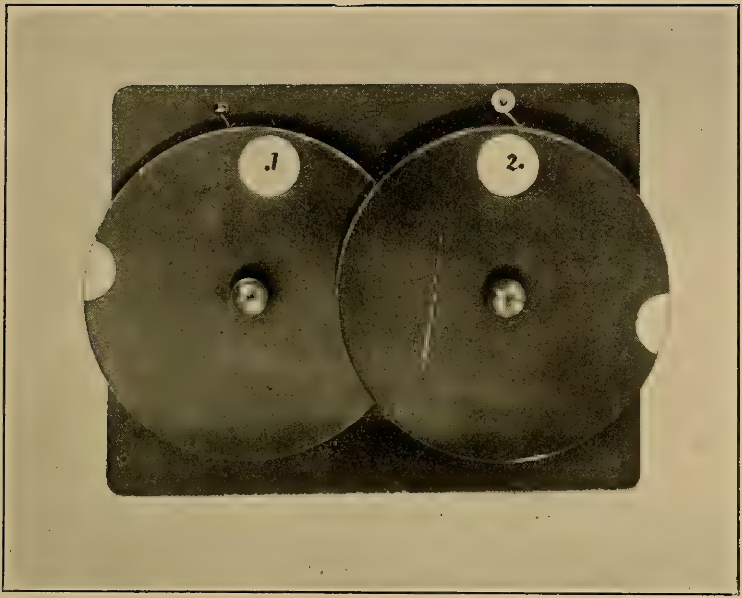


PLATE 47.—The X-Ray Actinometer. This ingenious device has a base which fits in the box of the regular fluoroscope after removing the screen. In the centre of the base is a small fluorescing window the size of a silver quarter. Upon the base are two revolving wheels. One is filled with ten layers of thin tin-foil. The other has ten layers of foil ten times as thick. To test the degree of radiance take out the regular screen and set the Actinometer in the fluoroscope. Clamp it on the front of the author's examining frame or on any convenient stand which will hold it in position at any measured distance from the tube. When the metal post in the centre of the miniature screen of the window casts a round spot shadow the base is square with the axis of the rays and ready for the tests. Next turn the wheels till the foil covering the window which fluoresces is just short of complete opacity. Then note the number of layers as marked on the registering window and the result is the penetrating capacity of the radiance as measured by the instrument. The windows of thin foil are marked .0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1. The windows of thick foil are marked 0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. The two wheels give a test range of 100 variations of penetration and densities. It was originated by the Bario-Vacuum Company, of New York, by whom it is made. It embodies very ingeniously the important principle of excluding all light around the testing field as demonstrated in the author's gauge. The plate shows the base of the instrument facing the reader with the fluoroscope hidden behind it in the line of sight.

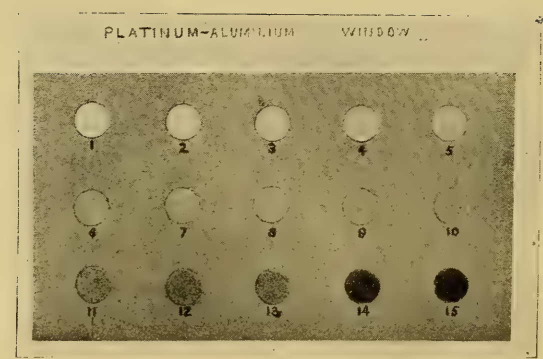


PLATE 48.—Many X-ray operators have employed test-plates with graduated windows like the above to measure the penetration of given rays. This cut is reproduced from a very elaborate article on the study of X-ray penetration, but a much clearer study could have been made by the author's gauge described in this chapter. The one fact that the whole field of the above windows is in the eye at the same time deprives the device of accurate value.

can also be very accurately determined by means of the shutters, and by distance. See Plates No. 45 and 46.

To further test screens for definition in addition to illumination, increase the light of the tube until the bars show best. Then compare sharpness of shadow with each screen. Both makers and users of fluoroscopes can thus standardize the highest attained efficiency, or note the defects of inferior screens. Records of these tests can be kept. Screens which have been in use for several years can be compared with new screens, when deterioration is suspected. The gauge is a practical necessity in the workshop of every manufacturer who makes either fluoroscopes or Crookes tubes, and should be in the office of every dealer who shows X-ray apparatus to customers. To the individual operator it is indispensable.

To test the maximum radiance of any tube, throw the set of shutters over the window, and stand the gauge at sufficient distance to obliterate all transparency of the field. Then slowly raise one shutter after the other, until the ring is dimly outlined. Next vary the exciting current and attempt to increase the light of the tube. If the gauge shows no increase in the brightness of the field shadow, the number of shutters over the window together with the distance between the gauge and the anode, will record the present capacity of the given tube. If the efficiency of the tube is increased, add shutters until they again nearly obliterate transparency, and record their number.

Next repeat the same test with reference to ascertaining the greatest number of shutters through which the entire shadow of the four cross-bars is defined. The measure of the working efficiency and defining power of the radiance at any given distance is the number of shutters of the gauge through which the shadow of the cross-bars can be made out with the fluoroscope.

To reproduce the same intensity of light at any other time, with the same or another tube, to secure a similar efficiency of penetration, refer to the record and adjust the radiance to the same distance and the same number of shutters.

It is important to the student to recognize the difference between *defining-power* of X-rays and mere diffused luminosity. The gauge is a beautiful test of this difference. Imagine yourself in a strange and very dark room filled with unfamiliar objects. A small candle will throw a diffused light throughout the room, and enable you to walk through it toward an object, but it will not define its details to the eye at a distance. The light has a low defining-power. To distinguish letters, the candle must be held close to the page. While such a glow will relieve the darkness its small practical working-power is general and not specific.

Now slowly turn up a gas-jet in the same room. As the light gradually rises in working efficiency coarse outlines of objects take the place of mere masses of shadow. A little higher working power and details appear to the eye. The working power required for a given purpose will be in ratio to the fineness of the definition of detail. An efficient light will enable you to read fine print at a normal distance from the eyes.

The philosophy of developing working-power with X-ray light is exactly the same. A tube may diffuse a general glow through the fluoroscope, yet have no better defining-power than the little candle in the dark-room. With a little increase of current and brighter X-rays we may see transparency commence through a large number of shutters covering the window of the penetration gauge. But not until the transparency is sufficient to do *defining work* does it become of practical value with the radiograph and the fluoroscope. The difference between a mere luminous effect of the rays and practical defining efficiency will be from four to six shutters of twenty-eight gauge thickness at twelve inches.

Operators who have not witnessed the demonstration of such a test have failed to recognize the cause of non-success in making examinations or radiographs with rays of less working-efficiency than the distance from the tube requires.

For practical standard work with tubes above an efficiency of X_4 with the gauge at twelve inches, the regular No. 28 set of shutters was selected by the author as a satisfactory thickness after four years of experience and numberless tests. For low-efficiency tubes requiring a finer discrimination, a second set of shutters is furnished of No. 36 Brown and Sharpe gauge which are about half the thickness of the others. Each is stamped from one to twenty, so that the number over the window can be known at a glance without counting. The set of thin shutters affords finer discrimination between different degrees of X-radiance, and is therefore especially adapted to testing low tubes or any tubes at unusual distances from the anode.

To compare the efficiency of different tubes, both for penetration and definition, use a definite exciting current, a definite distance between the gauge and the anode, and note the first perceptible appearance of the window for *commencing penetration*, and the first sharp appearance of the bars for *full penetration and definition.* The number of shutters required by each tube, other conditions being equal, will measure the difference in efficiency. In this way the author has rapidly tested twenty-five tubes at a time. No maker of tubes should be without this testing-gauge.

To test the comparative efficiency of different exciting currents with a given tube set up the maximum action of each and apply the same test.

To test the relative reduction of intensity in proportion to the increase of distance from the tube, establish the maximum radiance with the gauge two inches from the tube-wall. Note the number of shutters through which the window can first be outlined and the number through which the bars can be defined. If the bars are visible through all the shutters, as will be the case with a fine tube, move the gauge back till distance creates a zero point of light and record the number of inches between the gauge and the anode. Then lift one shutter and note the increased entrance of light. Lift a second shutter, note the increased light, and move back the gauge till the distance again reduces the transparency to zero. Record the exact distance, lift two more shutters, and move back the gauge till the light is dimmed to zero. Repeat the steps till all the shutters but one are removed. The relation of distance to the intensity of X-ray penetration will be indicated by the shutters. It was early stated that X-radiance followed the law of inverse squares. This is now known to be an error. Tests with the author's standardizing gauge will define the facts in feet and inches. With this gauge we can rate X-ray light as practically and correctly as we can measure any other light.

As a corollary to the above we arrive at the means of inaugurating scientific standards of time and distance in X-ray photographic exposures for each part of the body. A given degree of X-radiance, up to the maximum, can be practically regulated by any operator who can regulate the dosage of his exciting current; or a shunt regulator can be employed. It can be ascertained by tests that at a standard distance—say, twenty inches—parts of approximate thickness and density require a certain degree of X-light, for a certain exposure-time, at a certain distance. For the thicker parts of the body a record establishing the requirements for certain results would save multitudes of guesswork trials with feebler rays, and the cost of many failures and disappointments.

Any institution having high-efficiency apparatus, adequate experience, facilities for standard development of a negative, and command of clinical material, could work out the different "shutter-powers" required with reference to thickness and age of bones and different parts of the body, and publish the ascertained ratings for the benefit of the profession. The guesswork of the present would then be replaced by methods of precision. The missing link in the standardization of radiographs would then be put into the hands of every expert and beginner, and with the correct fixing of postures to eliminate distortion the popular chaos which has existed in this field of surgical examination prior to this date would give place to methods of scientific exactness. The author lacks time to do this.

Recording X-Ray Intensities.—In private experiments and in the many uses which the individual operator will make of this gauge the records made should note the measured distance between the surface of the gauge and the focus point of the rays, the dosage of the electrical current, the number of shutters through which light is first visible, and the number of shutters through which the bars are first defined, together with the resistance vacuum of the tube. If a Static machine is used, record the speed of the plates and exactly how the current is interrupted, with reference to spark length and polarity. If the direct constant current is taken from the prime conductors the fact should be noted. All these details can be entered in a single line by means of a few abbreviations and figures. Single letters will indicate the leading points.

The degree of radiance itself is indicated in the most practical and simplest manner, by simply adding the number of shutters to the letter X, as X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_{10}, X_{12}, X_{15}, X_{18}, X_{20}, etc. If other factors were always equal the mere mention of X with its proper exponent would furnish standard ratings for published reports and private work. But as the other factors are variable, it is necessary in a report to state the distance from the tube at which the degree of light was measured, as well as the vacuum of the tube which discharged the light and the dosage of the electric current which created it. When, however, in ordinary work it is only necessary to reproduce a certain degree of X-light with the operator's own apparatus, and at his preferred distance, it is only necessary to know the X-rating and adjust the tube till it produces the same.

Standardization of the Gauge.—To constitute this instrument a *standard official gauge*, so that all reports would have the same meaning, it is only necessary for all manufacturers to adopt the standard shutter of twenty-eight Brown and Sharpe gauge for the thicker set, and thirty-six B. and S. gauge for the thin set. Unless a uniform standard is adopted experiments will only have an individual value. The gauge, however, is not designed solely for scientific experiments, but is a practical working instrument for daily use with all who do X-ray work.

My now historic "Manual of Static Electricity in X-Ray and Therapeutic Uses," written in February, 1897, refers to my use of several layers of sheet-metal covering the entire fluorescing screen in measuring X-ray effects. The personal instruction of the author to physicians and surgeons for the next three years demonstrated the principle of this gauge. In 1900 I had it made up in the present standard form. It at once occurs to many who theorize about the matter that *brass* varies in its alloys, and that a pure metal, such as electrolytic copper or pure tin, etc., should be selected for the shutters. Practical experience shows that this theory is a refinement without value. The fluoroscope and the human eye cannot carry discriminations of degrees of light to so exquisite a point as to note the difference in ratios of alloy in different sheets of brass of the same thickness. Brass was chosen because it is a universal and cheap metal, easily worked, always obtainable in sheets rolled to standard gauge, and can be supplied by dealers anywhere. Its commercial convenience outweighs theoretical drawbacks which have no weight in practice.

Remarks.—This practical and reliable measuring instrument disposes of several theories about tubes and their differences. It makes the maker of tubes sure of his product and enables the buyer to select or reject them with precision. It weighs a tube in a balance of infallible accuracy, and mistake or deception is impossible. If found wanting, the gauge measures what it lacks. It is an indispensable part of equipment. To be without it in scientific X-ray work is somewhat like being at sea without a compass or sailor's log. To possess the gauge is to know exactly what tube, current, and screen are doing, and with this knowledge radiography becomes more nearly definite and certain.

The question is often asked why a tube may be good with a screen and poor for negatives, or why, of two tubes that appear to act just alike, one will make a good picture and the other fail. The measurement of tubes with this gauge removes these questions from discussion. A maker brought the author two exactly similar plain tubes for tests. Both glowed with nearly the same fine green luminosity of the glass to ordinary observation. The casual fluoroscopic glance at the hand was the maker's test. He remarked that they were both "good tubes." One showed the hand a little brighter than the other, but the usual moving of the screen back and forth in these observations ignores measured standards of distance and the eye notes only gross light and shade. Definite tests with the gauge at a fixed distance of twelve inches proved that one tube showed the bars through only *two* shutters, while the other showed them through *twelve*. The difference of ten shutters in the capacity of two tubes which looked near enough alike to deceive an experienced manufacturer indicates what the different results would be on a photographic plate. An exposure with these tubes for the same time, at the same distance, with the same current, would not be the same thing at all. To be alike, the X-radiance must be equal. The many crude ideas remaining extant in regard to supposed differences of photographic activity between different tubes and the same tubes at different times, are the result of working without this instrument, which affords an exact measure.

Penetration Register.—The Author's Penetration Register is designed to mark on the negative the *total penetration* of the exposure. Such an automatic registering device would appear to possess value in medico-legal cases, or in any case in which it was afterward important to know, or to prove how long the patient was subjected to the action of X-rays.

It consists of a graduated series of layers of standard gauge No. 28, sheet-brass, the same as the standard shutters of the author's penetration gauge, or X-ray meter. The layers run from one to eight in the sample, but for high intensities of radiance this number can be greatly increased. Numerals attached to the base indicate the number of layers penetrated during an exposure. The last figure which shows on the negative registers the total penetration. For practical use simply place it on the plate outside the wrapper and in close relation to the diagnostic field but outside of it. See Frontispiece.

This register may also be made useful in making tests to become familiar with average exposure-times for normal penetration with the apparatus in your own office. It may be objected that such a piece of metal on the plate will unbalance the development of fine shadows, but in cases when the register would be employed this would not be a momentous drawback.

Photometers and Radiometers.—These two words and also "Ray-meter" and "Skia-meter" have been applied to devices for roughly noting the penetration of the rays from any given tube. They are usually made with increasing layers of thin metal backed by lead numerals, or a bar of metal with a series of holes. The indicating numeral or hole on the border-line of opacity will mark the thickness of metal through which the rays show light. A number of writers have described variations in the device and its uses. An elaboration of the *skiameter* for quite a different purpose is described in another section.

When, however, the small aluminum "ray-meter" is observed through a fluoroscope the eye is filled with the luminous field, which is usually much larger than the area of the meter. Fine discriminations of the degrees of shadow are thus lost, for the eye must be confronted by a dark field in order to detect in it the last fading of a dim shadow.

As commonly used these pocket devices and the fluoroscope are shifted in the hands of the operator, and no definite distance or relation to the tube is represented by the test. Being random, it signifies little when done. In marked contrast to these devices of casual value is the author's standard penetration gauge. Excluding all conflicting light from the entire field of test, and using a standard measured distance from the tube, it becomes a more scientific instrument of greater precision as a ray-*meter* than any other which has come to our notice.

CHAPTER XXI

THE AUTHOR'S DISTORTION LANDMARK

A Device for X-Ray Negatives. Medico-Legal Proof of Position and Distance of Tube During Exposures. Special Landmarks.

Where was the tube (and the X-ray focus) when the negative was made? This question may sometimes have medico-legal importance, but at all times the surgeon wants the information for diagnosis. The instrument to be described answers the question with scientific precision. See Plates No. 49 and 50.

1. It automatically certifies on the plate to the distance of the anode and the perpendicularity or slant of the axis of the rays.

2. It certifies to any displacement of the shadows of the proper diagnostic field caused by an inaccurate position of the plate or tube during an exposure.

3. It images on the plate the direction and amount of all deviations of the axis of the rays from the essential perpendicular.

4. It indicates an exact measurement of the distance of the anode from the film, so that a witness in a case in court who testified that the tube was at some other distance would be refuted by the internal evidence of the negative.

It is impossible to tamper with this evidence, or alter its plain findings if the landmark is used as designed. If fraud was undertaken, the obvious deviation of the shadow when confronted by a standard landmark would convict the witness of the attempt. In any case, the landmark will not only stigmatize fraud, but will throw careless guesswork out of court and compel a more correct picture of the part. An accurate picture must shadow the parts in the relation which appears when the path of the rays forms a right angle with the plane of the negative. Any deviation from an exact perpendicular creates proportionate obliquity and mars the diagnostic interpretation of some pictures. When the plate has been exposed after the usual precaution to insure perpendicular rays upon the part, the shadow of the author's landmark on the negative affords final and permanent proof of the accuracy or error of the preceding steps.

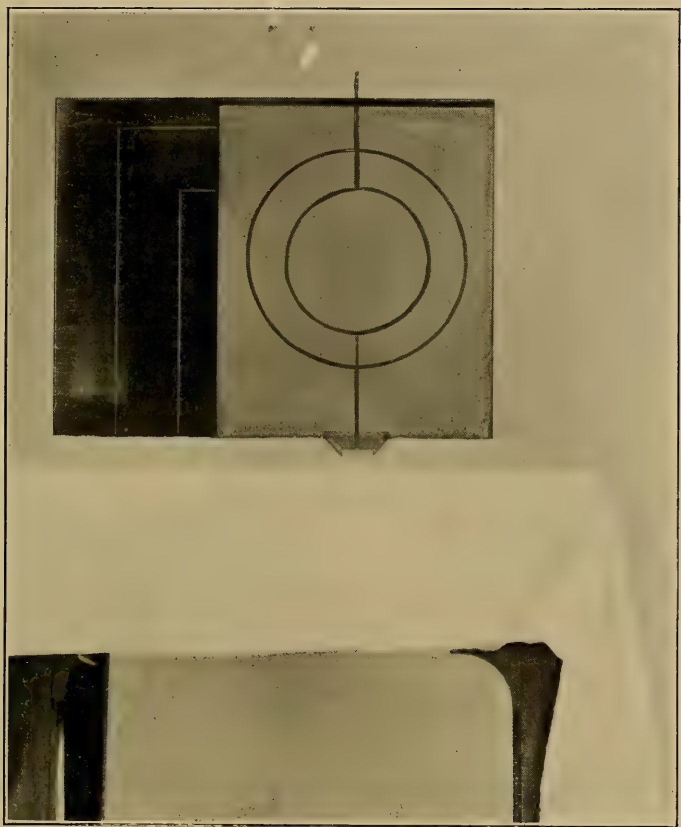


PLATE 49.—Author's Distortion Landmark Seen from the Front. The landmark is on the wrapper of a photographic plate which is on the brass base of the Author's Position Finder. The upper and lower cross-bars are in register and show as one shadow. The relative sizes of the two circles appear as they faced the camera. At twenty inches from the focus of the tube the divergence of the rays brings the upper and smaller circle into register with the lower and larger circle so that the shadows merge if the register is exact, or by their deviation prove the precise amount of "distortion" that occurred. See frontispiece for example of result in radiograph. See next plate for instruction in method of use.

PLATE 50.—Author's Distortion Landmark. Method of use. This Instruction Plate shows the tube centred at twenty inches over the photographic plate on the base of the Author's Position Finder, as taught in the text. In the radiograph that will result from this exposure the negative will contain medico-legal proof of the position and distance of the tube, the field of the axis of the rays, and the degree of "distortion" present, if any has been caused. See frontispiece for example of radiographic evidence thus obtained.

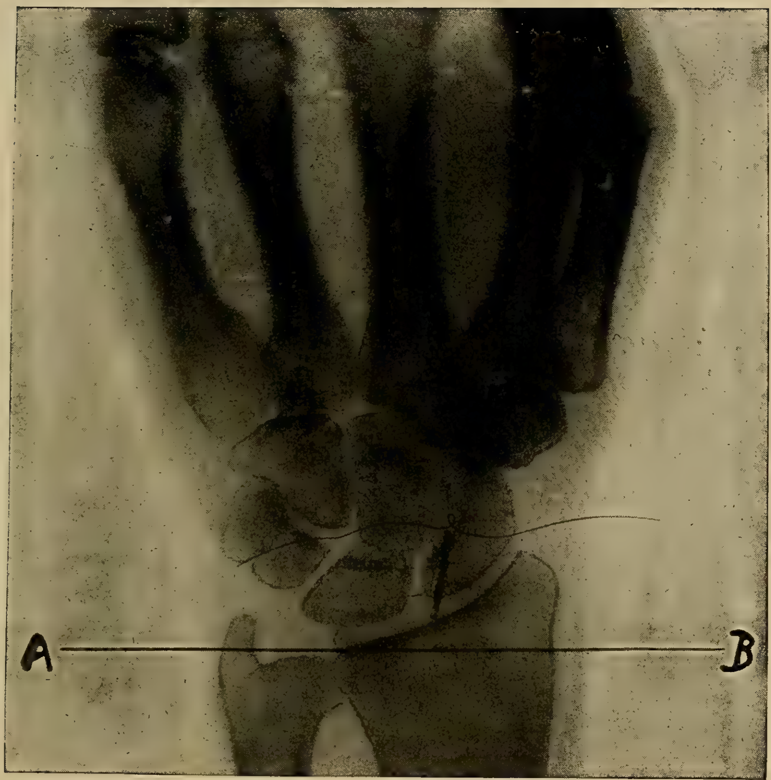


PLATE 51.—Illustrating a normal wrist in which a piece of needle has been imbedded. It also illustrates the method of marking a "diagnosticating" line at right angles to the long axis of the arm when studying radiographs of old injuries of the wrist. "This line is the only sure safeguard for rightly interpreting old healed-up fractures of the lower end of the radius. The whole of the articular surface of the radius, when in its normal position, is on a plane situated on the hand side of the diagnosticating line. When the radial styloid is on a level with that of the ulnar it is considered to establish the diagnosis of a Colles's fracture." The loop of wire seen in this picture was employed to localize the point of entrance of the needle. (Rebman, Ltd.)

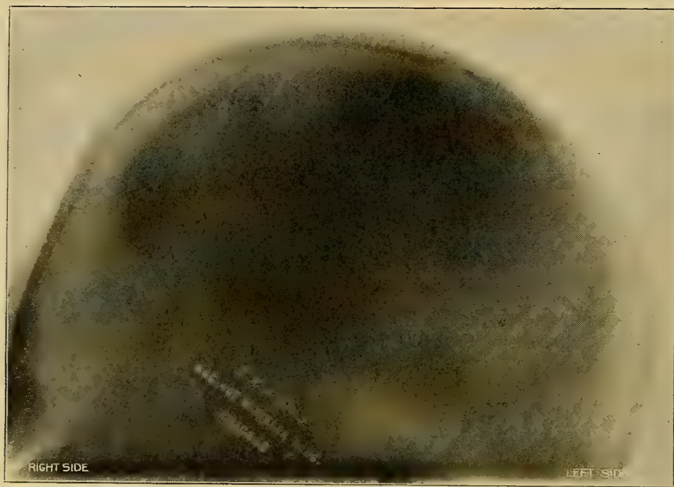


PLATE 52 (1).—Cystic tumor in the brain in child who was blind and partially paralyzed. Arrow in upper left-hand corner points to the tumor. The plate below shows the lateral cross-section of same case, while this plate gives the antero-posterior view. Compare both radiographs. The reduced half-tone loses much of the original negatives.

PLATE 52 (2).—Lateral view of above case of cystic tumor in the brain of child. Case operated on and recovered, verifying the radiographs.

X-ray work may be considered *accurate* when *it attains its object.* In some pictures the trained eye of the expert observer can note at a glance the slant of the shadows and deduce from them the position of the tube without a registering landmark, but the adoption of a standard landmark to certify on the plate the relation of the axis of the rays to the plane of the part examined will do much to remove doubt as to how the anatomical relations of the recorded shadows should be interpreted. For this purpose, when needed, the author has devised a pair of thin steel circles mounted rigidly on a support as shown in the Instruction Plates. As the majority of radiographs are made on films not smaller than 8 × 10 the base circle is seven inches in diameter. This is large enough to easily embrace all the main diagnostic field on any size of plate, however big, within which the shadows show the minimum of distortion, and is fully equal to the field of the ordinary fluoroscope. Therefore, this diameter has been selected for the lower register in average work.

The upper registering-circle mounted eight inches above the lower circle has the diameter (four and one-fourth inches) shown by my divergence chart to coincide with the lines converging from a seven-inch cone toward the anode at the standardized distance. With the base of the cone twenty inches from the anode, the cross section at twelve inches from the anode will be four and one-fourth inches, as shown by the chart.

Before using this register in radiography become familiar with its action through the fluoroscope. Observe the shadows cast on the screen by the circles when the larger one is in contact with the fluoroscope and the upper register is approximately in line with the tube. Note at once that the shadow of the circle in *contact* with the photographic plate will be sharp and clear. Its shadow, therefore, identifies it beyond question. Note the hazy and enlarged shadow cast by the distant circle and you will recognize it without fail when it is similarly registered on the plate in a skiagraph. Now shift the device in all directions out of the axis of the rays, and note how the *changing relations* of the two shadows indicate the *position* of the focus of the tube. Remove the eyes from the fluoroscope and prove the position of the tube till at the various distances and deflections you can promptly say where the tube is that causes the shadow.

Now hold the screen and circles so that the centres engage the anode-focus of the rays, and the two shadows will now not only be round instead of elliptical (as when out of a right angle), but the circumferences will be equidistant at all points, and the side-bars will register also as a single line. Shift the distance back and forth to test the effects on the shadows, and finally note that when the circles are centred correctly at twenty inches the two make a single shadow on the screen. When they do so on a plate and so appear in the negative they are *proof of the centred and right-angled relation of the plate at twenty inches from the anode source of rays.* When they deviate from a perfect register on the plate the direction and extent of the malposition of the tube is shown by the axis of the ellipse and the overlapping of the shadows of the circles. See Frontispiece.

In this description the author has considered only a single pair of circles of medium size. The operator who so wishes can as easily have several sizes, larger and smaller, and standardized for any desired distance. Three pairs would make a useful set. The proper measurements can be obtained from the Divergence Chart.

As a study of what is called *distortion* from the rays ten minutes actual observation of these circles, changing their apparent relation and situation as you turn their axis to the right or left, or up or down, will teach more of the causes of distortion, and how to avoid them, than will a year of the random work so common among beginners.

Having studied the shadows with the fluoroscope we are prepared to use the landmark in photography. After the plate, patient, and tube are all in position simply slip the device under the part on the plate so that the lower circle will outline the central field. The pressure or weight of the part will keep it in place. The upper circle then registers exactly above it in the path of the rays. To centre the landmark to correspond to the centre of the plate have a piece of stiff cardboard cut round to fit the circumference of the upper circle and pierced with a central hole. After centering the position-finder and before unscrewing the rod, slip this disk over the rod and then move the landmark until the upper circle engages the cardboard disk. Then remove the cardboard, unscrew the rod, leave the landmark in this position, carefully place the photographic plate under it, insert the part to be radiographed, and proceed with the exposure. While the standard of eight inches has been taken as an average distance *between* the rings, and is sufficient to admit most parts of ordinary patients, yet other pairs, both larger and smaller, may be kept on hand for all requirements of an extensive practice. The principle is the same in all cases. The circles will not interfere in any serious way with the diagnostic shadows on any larger plate, as they merely mark a ring around the central field. When not important to use them as proof of the procedure employed they can be set aside. Being extremely simple and made at small expense their value makes them quite an essential feature of X-ray equipment.

Proof of Distance of the Tube.—An operator doing a large amount of work will have on hand several pairs of circles standardized for different sizes of plates, and different exposing distances from the tube. The principle is exactly the same whether the landmark is large or small. The sample above described was constructed to merge the two rings in one shadow at twenty inches from the tube.

Shut one eye, and holding the landmark at arm's length with the smallest ring nearest the open eye, sight through the centre of the distant ring. Hold a yardstick also in front of the eye with the end resting at the side of the orbit. Now shift the distance of the landmark and note that all deviations in a perpendicular axis remove the two rings from a common register, but that in a perfect axis the eye will see but the shadow of a single ring, and the cross-bar supports will register as single lines when the yardstick shows that the largest ring is exactly twenty inches from the source of sight.

Move the landmark nearer, and note the change in the relative size of the two rings. Move it farther away, and note the altered size of the small ring. At all other distances except the standardized one of twenty inches, the rings make *two* shadows. The sharp-cut shadow in the radiograph will always be the one close to the film, the blurred and hazy shadow will always be the distant ring. When the circles are out of register in the radiograph and the distant ring is either larger or smaller than the ring against the film, measure the diameter of the shadow on the negative with a foot-rule; then turn to the author's divergence chart, and find the same diameter across the diverging red lines. This shows the exact distance required to alter the real diameter of the small ring of the landmark to the diameter imaged on the plate, and proves the distance of the exposure. Whether the tube was at twelve, sixteen, twenty-four, or thirty or more inches from the plate can thus be determined by the aid of the author's divergence chart.

So far as known this Distortion Landmark is entirely original with the author. To insure accuracy it must be correctly made, and not put together by rule of thumb. Proper accuracy in centering the circles will be secured by constructing the device upon a wooden cone of the required diameter at the base, and turned to a point to represent the focus of the rays. This is important.

No other device has hitherto been made which will perform the service of this landmark. It can be cheaply made. Make one and test its workings.

Special Landmarks.—For various purposes it is useful to mark the negative with devices of opaque bodies. A small piece of fuse-wire fixed to a part with adhesive plaster is a very common landmark employed in localizing foreign bodies. Numbers made of bent wire are laid upon one corner of the plate to identify it. Sometimes a stencil bearing the operator's name is used. The capital letters R and L are used to indicate right and left quadrants of the plate. Circles and bars of various sizes and thicknesses, perforated with vertical pinholes, are also used as landmarks to test the angle of the exposure. A small coin is sometimes fastened to a part to identify the site of some transparent anatomical feature in the picture, as, for instance, the nipple, in examining the heart. Cross-wires are frequently used. The needs of different branches of work suggest to the operator such landmarks as will best serve his own purpose.

A simple and useful landmark is a small thin metal washer. When stuck on the skin with a bit of plaster to mark the spot on which the anode is focussed it leaves its shadow on the negative as a reference point. Before removing it from the skin make a more permanent mark with some stain applied in its open centre. Anything fixed in the negative that will indicate the centre of the focus, the upper right-hand quadrant of the plate, and the part exposed, if it is not self-evident in the picture, will aid in the interpretation of the negative. All practised workers attend to these points.

Note, however, that the negative will afford no legal proof that the anode-focus was actually in the axis perpendicular to one washer. The operator may state that the washer is at the foot of the axis, but in the absence of a second reference-point the fact cannot be proved. The author's Distortion Landmark is the only device so far offered the profession that embodies every proof desired.

CHAPTER XXII

THE AUTHOR'S POSITION-FINDER

An Accurate Means of Centering Plate, Patient, and Tube for Radiographs. A Study of Precision in Methods.

Next in the series of the author's aids to accuracy in X-ray work is a simple and effective Position-Finder. It performs a service similar to that of the "finder" on the camera. It *finds* the relating positions which the source of X-light, the axis of the rays, the photographic plate, and the centre of the diagnostic field, must bear to each other in order to produce a non-distorted shadow on the sensitive film. The same principle applies to the use of the fluoroscope. The author's gauge, landmark, and finder are three supplementing essentials which enable us to standardize three steps in skiagraphy *with the precision of mechanics.* With these instruments at hand the degree of X-radiance at any distance, the correct position of the diagnostic field, and the pictured evidence of accuracy, are scientifically demonstrated and removed from guesswork.

As shown by our divergence chart, every point on the circumference of a hemisphere in front of the anode is equidistant from the focus, and at right angles to the rays reaching it. Therefore, a hemispherical photographic film coinciding with any part of the radiant field would make a non-distorted picture throughout its entire extent, provided that the object radiographed conformed to the same shape. It is not so with a *flat* plate, but a glance at the chart also shows that any given ray in any part of the field will become a *perpendicular* and serve as the axis for a non-distorted shadow, if the surface of the plate is placed under it at right angles to it. While this fact has been generally recognized in theory many deviations from it occur in practice. The original position-finder was simply the casual glance of the operator, who put the tube where he thought was "about right." The next advance on this was the plumb-line. A plumb will drop from the point of a stick or the finger of the operator, and will indicate the perpendicular very closely, but it does not level the photographic plate at right angles to this perpendicular. It does not get any nearer than the wall of the tube to the actual focus-point on the platinum plate, and it is useless for lateral exposures and all others except the vertical. Within narrow limitations, however, it helps the operator to make a close guess. An *instrument of precision* is quite another matter, and the author offers such an instrument in his Position-Finder. See Plates No. 53, 54, 55, and 56.

The device is primarily a base and a straight rod with a small canal in it. A wooden base and a thin metal rod can constitute a scientific position-finder of the simplest character, but to serve a double purpose, as will be explained, we have made the base of brass about an eighth of an inch thick, eleven inches wide, and fourteen inches long. The front surface is marked with lines to indicate seven sizes of photographic plates, from 4 × 5 to 11 × 14. All sizes start from the lower right-hand corner of the base. At the exact centre of each plate the base contains a hole with a screw-thread in it. Near each hole is stamped in plain figures the size of plate which it *centres*. When any plate of any size is laid upon this base so that its side and end coincide with the same borders of the base, its centre will be exactly in the axis of the rays which the Position-Finder has previously located at right angles.

To study the principle of finding this axis make the following experiment: Excite a tube and stand in front of it with the fluoroscope as if for an examination. Now, with the left hand hold a steel knitting-needle in front of the screen with one end touching the fluoroscope and the other pointing to the tube. Make different lateral movements with the fluoroscope and note the length of shadow cast by the knitting-needle. Also hold the fluoroscope at right angles to the tube and slant the needle at different angles. This is excellent study of the *cause* of distortion. Also note that by watching the shadow and moving the needle so as to shorten it you finally reduce all its length to a mere round *spot*, and distorting obliquity has been eliminated in the line of the needle. *The needle is now exactly in the axis of the rays, and any picture taken under the same relation to the tube will show a non-distorted shadow within the exact field of the axis.*

Substitute for the needle a hollow tube, say a foot long, and with a lumen about the size of the knitting-needle. With the eye at one end sight it toward any gas or electric-light. It is like sighting a gun or bringing an object within the field of the telescope. In order to see the object the rays of light must pass through the narrow hole in the tube in the visual axis of the eye. Now do the same thing with an X-ray tube. Regulate the current so as to just redden and reveal the focus-point on the anode. With the opposite eye closed sight through the tube and engage the focus. Also note how slight a deviation loses the focus. This teaches true *alignment*.

Next hold the same hollow tube in front of the fluoroscope and endeavor to engage the focus. Note that when it points at any other part of the anode the hollow rod casts a shadow of some length instead of a round spot, but when the focus is actually engaged the wall of the rod will cast the shadow of a small ring with a round transparent centre, proving that the rays pass through the lumen in a straight line to the fluoroscope. In making this last experiment use a tube-holder to support the hollow rod, and afterward remove the fluoroscope and with the ordinary eye look through the canal and observe that the red focus-spot on the anode is visible through it. Also observe the direction of the rod with relation to the plane of the anode. Without moving the tube, observe that you can swing the rod to *any other place in an arc of a circle* at any distance from the tube and *still engage the focus*. But note that even the slightest movement in a *horizontal* direction will throw the rod out of axis, so that the focus cannot be seen through it. These tests can be made with improvised material by any operator. *They demonstrate both the principle and the scientific accuracy of the author's Position-Finder.*

To use the instrument in practice screw the hollow rod into the hole which marks the centre of the plate which you desire to use. Connect the tube as you desire to use it, and put the base of the finder about where you would ordinarily put the photographic plate for the exposure. There are now three methods by which the *exact* position for the plate can be found.

1. Without exciting the tube shut one eye and sight down the line of the rod from the known focus-point of the anode. This off-hand method is a substitute for the plumb-line, is more accurate, is adapted to any position, and is correct enough for all ordinary work. It is not, however, the most *precise* method. Plate No. 53.

2. With the tube in action and just showing the red spot on the anode to locate the focus, sight through the finder from the back of the base and shift it till the red spot appears in the field. Let the base rest in this situation, which is the exact position for the plate. Or,

3. With the hollow rod pointing at right angles from the base, place the fluoroscope against the back directly over the hole into which the rod is screwed. Carefully shift the finder till the lumen of the tube is seen as a round transparent spot, indicating that the rays have passed directly through the canal of the metal rod. This is the precise centre of the given field of X-rays. Plate No. 55.

After using whichever one of the above methods is most convenient in a given case, simply unscrew the rod and lay it aside. The base remains in the right position for the radiograph and has secured both elements of accuracy, viz.: the *perpendicular* and the *horizontal*, which a plumb-line does not do. Throughout the process the tube remains unchanged. As shifting a tube to suit a fixed field for the plate is much more difficult than to find a plate-field for a fixed tube, the advantage of this Position-Finder is manifest. But it has other advantages.

Now bring in a photographic plate. Place it in position upon the base of the finder. The simple act of laying it on the finder at once *automatically squares, levels, and centres it.* It only remains to place the patient on the plate and the part is automatically brought into correct relation with the tube, and the usual tedious process of adjusting the tube after the patient is placed is entirely eliminated.

If a second exposure is required the second plate can be next automatically centred in exactly the same field occupied by the first. Before placing the part over the plate mark the skin with both the centre and circumference of the diagnostic field; lay the marked centre on the centre also marked on the envelope containing the photographic plate, and you at once secure the best relation of the diagnostic field to eliminate distortion without any other measurements, adjustments, or apparatus of any kind. The four centres are lined in one perpendicular axis.

To mark the centre on the envelope simply draw with a ruler and pencil two cross diagonal lines from the opposite corners of the plate. The intersection of this X will correspond with the centre of the film and the exact axis of the central rays, for it will be the position denoted by the rod of the Finder which locates the axis. If special marking of the diagnostic field on the negative is desired simply fasten a ring of fine copper-wire on the skin of the patient with strips of adhesive plaster, and when the negative is finished it will be marked with the same ring.

It is also obvious that *this method of centering the diagnostic field always indicates to the operator the essential part of the negative to study for diagnosis.* This is especially useful when a large negative is made. In addition to rendering the above services the heavy and rigid metallic base of the Position-Finder gives a firm unbending support to a glass plate, preventing breakage under a heavy body. It also *backs* the plate with a dense protective which is opaque both to direct and secondary X-rays; thus sharpening defini-

PLATE 53.—Author's Position Finder. Ready method of centring plate with focus of tube, as taught in the text. Operator is sighting down anode and along rod to base. The lines on the base show different sizes of photographic plates, each of which has a centred hole for the rod. Shift the base with the hands till the focus is sighted, then remove the rod and lay the plate on the base film side up. Then place the part to be radiographed on the plate with its marked centre on the centre of the light-proof wrappers. See text for full directions.

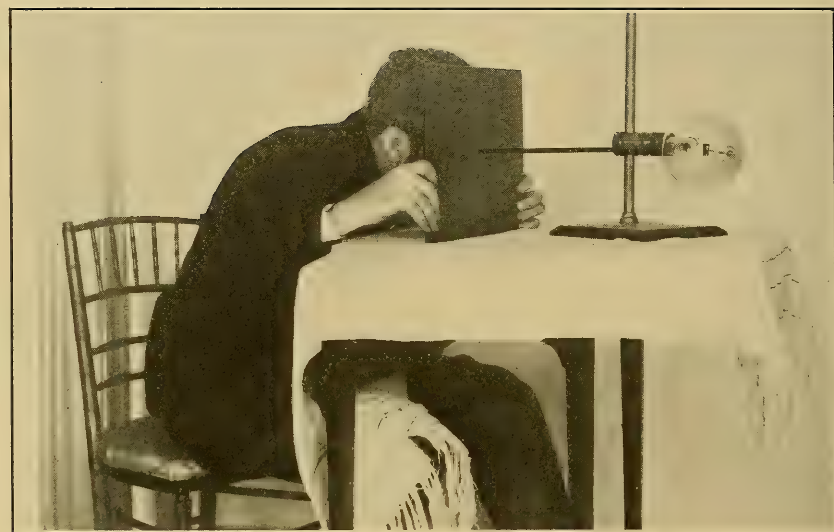


PLATE 54.—Author's Position Finder. Sighting through channel of rod to find axis of rays from the tube-focus. See text for full description of method.

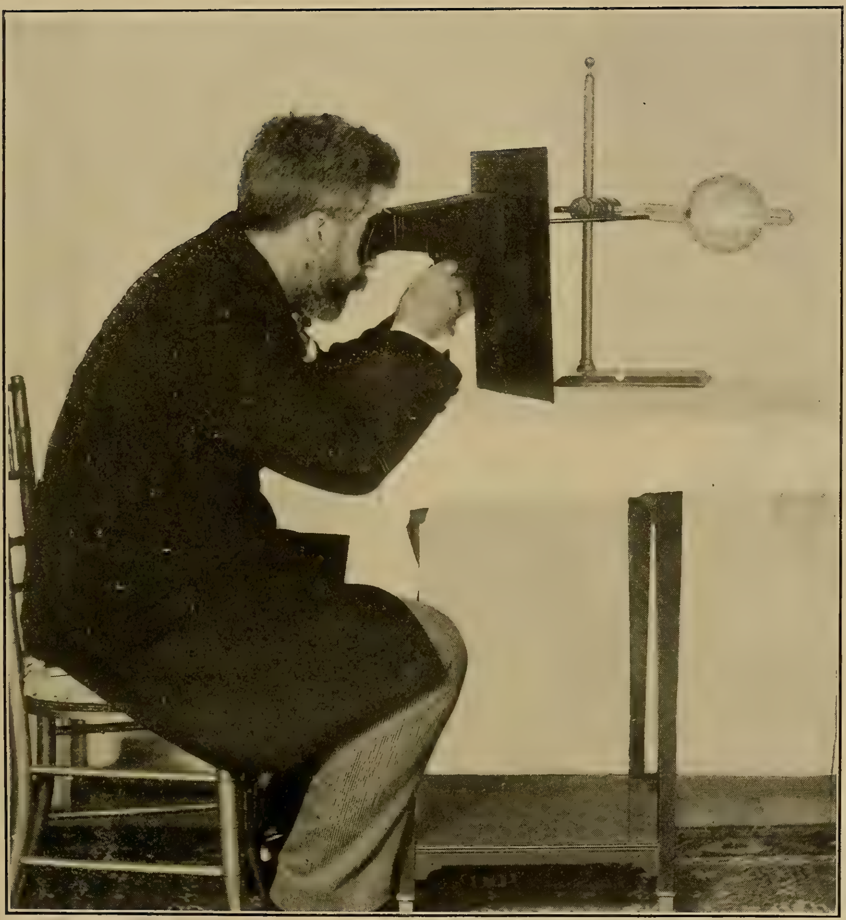


PLATE 55.—Author's Position Finder. Sighting shadow of rod with fluoroscope as described in text. The three Instruction Plates of this instrument sufficiently teach how to secure with its aid an exact central field in the axis of the X-rays, and, when found, to locate the part in this position for radiography. It will be seen also that the flat metal base makes a secure support for a glass-plate, placed, for instance, under a patient who is on a canvas stretcher. It prevents breakage, absorbs the rays, and is a valuable device.

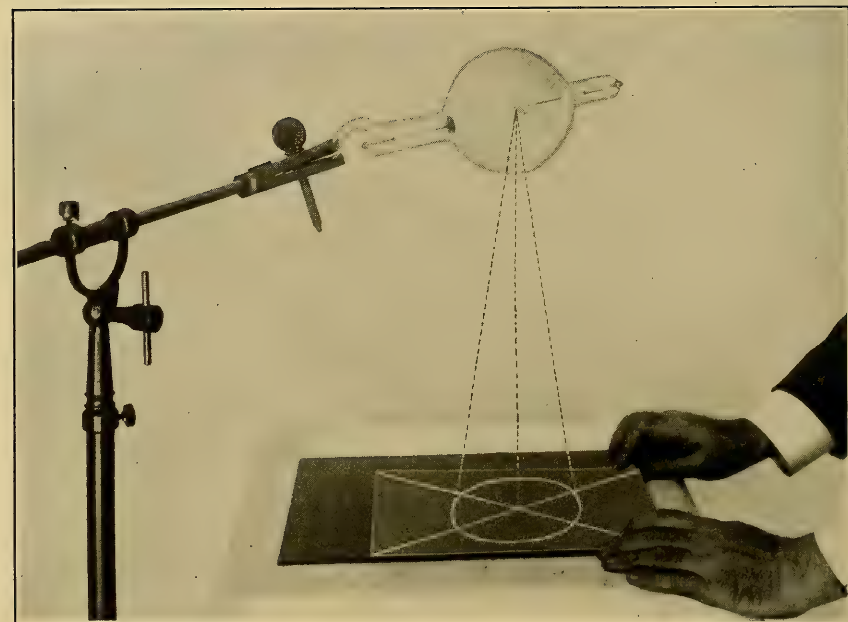


PLATE 56.—Diagnostic Field and Axis of Rays as shown by Author's Position Finder and Landmark. Having sighted the rod of the Position Finder and secured the focus remove the rod. Draw two diagonal lines across the light-proof envelope of the plate from corner to corner and their intersection marks the centre of the film. The vertical dotted line occupies the place of the rod and is the axis of the rays, carrying down shadows to the centre without divergence or distortion. As the rays form a cone they have a circular field on the film, which is shown by the ring. The slant of the side rays is shown by the diverging lines. With these aids to accuracy all errors of position area voidable. See study in divergence and distortion in the text.

tion, preventing blurring, and shortening the time of exposure, as is explained in another chapter.

In accurate radiography certain firm supports are needed for the various parts of the body. These are tables, stands, blocks of wood, frames, etc., such as ingenious operators have devised for their special use. The tube-holder is sometimes separate, and sometimes attached to these tables. The slightest move of either the table or the Crookes tube displaces the focus, and an *uncentred* negative results. It is the author's design to have a bent-arm tube-holder fixed permanently to one side of the base of the Position-Finder. The device then becomes connected with the tube. When the tube is once focussed it remains so, and the base to which it is fixed can be moved anywhere and shifted to any position adapted to the patient without altering the correct relation of the plate. Exposure after exposure can be made with accuracy and without delay, with no subsequent repetition of sighting the focus. The base can be clamped upon any table, stand, or frame, and thus simplify matters by affording a permanent adjustment. Nothing has been said here about the distance of the tube from the plate. This is fully considered in another place.

In discussing the wrong interpretation frequently made by surgeons of the "skiagraphic testimony regarding Colles's fracture," Thomas aptly remarks that *you cannot see through a key-hole unless your eye is in the right place.* X-rays will not show clearly a line of fracture unless the anode is perpendicular over the line of fracture, with the bones so placed that the fracture has a chance to show. He remarks that if special attention were given by surgeons to the position of the anode while making radiographs there would be less criticism of the results. Stress is laid upon the importance of "using a plumb-line in placing the tube," and a number of somewhat complex suggestions have been given to assist the operator in getting the tube fixed properly *over the part.* It seems to me that a much simpler way is offered by my position-finder. This entirely ignores all processes which first prepare the part for exposure and then make efforts to fix the tube directly over it. It simply, and at once, automatically centres the axes of the rays with the centre of the photographic plate, and over this marked centre the part can be laid upon the envelope with exact reference to the cross lines. It is only necessary to lay the line of fracture on the line marked on the envelope of the plate without regard to the tube. In other words, it is easier to adjust a part *under* a tube than to adjust a tube *over* a part. The Position-Finder makes this process almost instantaneous with a little practice.

CHAPTER XXIII

AUTHOR'S ONE-MINUTE LOCALIZER AND EXAMINING FRAME

Its Three Uses. Directions for Fluoroscopic Work. Localizing Technics. How to Readily Locate a Bullet in the Cranium.

Localization may be desired for several other reasons than the removal of a foreign body. There are three phases to the requirements of localization. It may be (1) general, (2) approximate, or (3) exact.

To obtain a *general idea* of the presence and situation of the foreign body, fracture, or other lesion correct inspection with the fluoroscope or a centred radiograph suffices.

To obtain *approximate localization*, especially as to depth, either the fluoroscope or the simple radiograph may suffice, but closer observation, some surface markings, and the relation of landmarks (or a stereoscopic view), is essential. When surgeons lose their present dread of approaching those finer fields of X-ray work in which the enthusiast-expert revels with delight the stereoscope will be the ideal means of observation for this purpose. Probably the details of stereoscopic X-ray work will gradually appear easier to the rank and file of the profession as average technic reaches a higher level and fewer men are content to risk their reputation by simply "slapping a plate under the part, putting a tube over it, and letting it go at that."

Exact localization requires more than the unaided fluoroscope or simple plane radiograph. It usually requires some mathematical computation to arrive at "depth," and all processes so far described with any form of localizer call for *two* exposures, *two* radiographs, or *two* observations of some kind in directions as nearly at right angles as possible with certain apparatus, and, with cross-thread methods, a shifting of the position of the tube. While an expert constantly doing this work can secure a result so quickly that the bystander thinks it is easy, yet when the average operator whose needs for the method are but occasional thinks of doing the same thing himself, it takes on difficulties that loom up large to deter. Simple things become unhandy when the hand is out of practice.

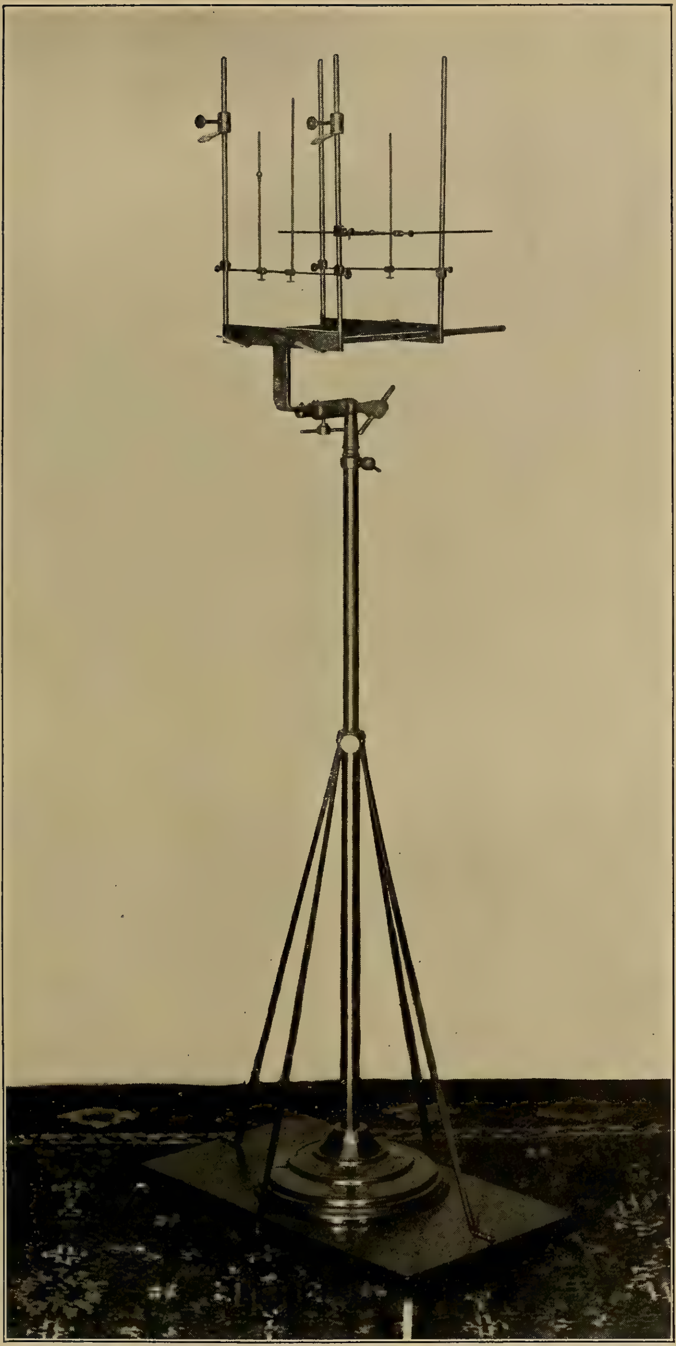


PLATE 58.—Author's Examining Frame and One-Minute Localizer.

See following page for description.

Author's Examining Frame and One-Minute Localizer.

This instruction plate illustrates the manner of setting up the Author's Examining Frame with clamps on front posts for holding the screen or fluoroscope, and the rods and markers in position for localization. The frame can be taken apart at any or all of these joints, and the examining frame lifts from the standard for use on a table-top when desired.

The upper pair of clamps hold the fluoroscope on the frame and can be moved up or down as desired. The bottom of the screen clamps in two foot-rests. A second pair of lower clamps like the upper ones is furnished, but are not shown in the photograph. They hold either an open screen or the regular fluoroscope.

The front and back horizontal rods, together with the front and back vertical rods, constitute the *markers* of the *axis* of the *rays* when they are adjusted in the line between the examiner's eye, the screen, and the focus of the tube. The intersection of each lateral with each vertical rod makes a right angle, and when the shadow of the part examined is placed in the two sides of the square at the point of intersection it is exactly in the *X-ray field of non-divergence* and *non-distortion.* The rays passing through this field are rectilinear at right-angles to the visual axis or to the photographic plate.

The *depthing* rod is adjustable antero-posteriorly on the rod, which is parallel to the axis of the rays between the front and back of the frame. On the depthing rod are the adjustable pin and ball which are used in localization as taught in the text.

A vertical rod bearing a sliding ball is carried by the front "marker." When slipped any distance to the left of the vertical rod of the marker it serves as a guide to the vertical line of any shadow over it at any level above the horizontal rod of the marker. The ball or pin on the depthing rod is guided to exactly this vertical line (over a bullet, for instance,) by sliding the depthing rod backward. That at once localizes the foreign body without any figuring or plotting out a diagram on paper, or measurements of any kind.

For use as a localizer the depthing rod is placed on a front side-post. It is removed when the frame is used for examining only. Notches one inch apart in the base aid the eye in off-hand estimates of distance. Set-screws permit all rods to be shifted to any and all positions needed in practice.

To adjust to height raise or lower the main post, which telescopes into the standard. To turn frame horizontally loosen the lower set-screw at head of post. To turn in antero-posterior arc loosen the set-screw just above. To turn in a lateral arc loosen the set-screw under the head at left of post. To adjust frame to width of part slide the rear half forward or backward as needed. To level the cross-rod markers loosen the set-screws at each end and slide to suit. Adjust the vertical rods in the same way. It is all done quickly with the briefest practice and has no complications. The *depthing rod*, the salient and original feature of this device, does not show well in the plate, owing to the position of the camera when photographed. It is the upper horizontal rod running half way across the figure toward the left post. It is adjusted by a set-screw to any position on the upper rod seen running back from the front right-hand post to beyond the rear post. To use the frame on a table simply lift it from the standard and lay it on the table.

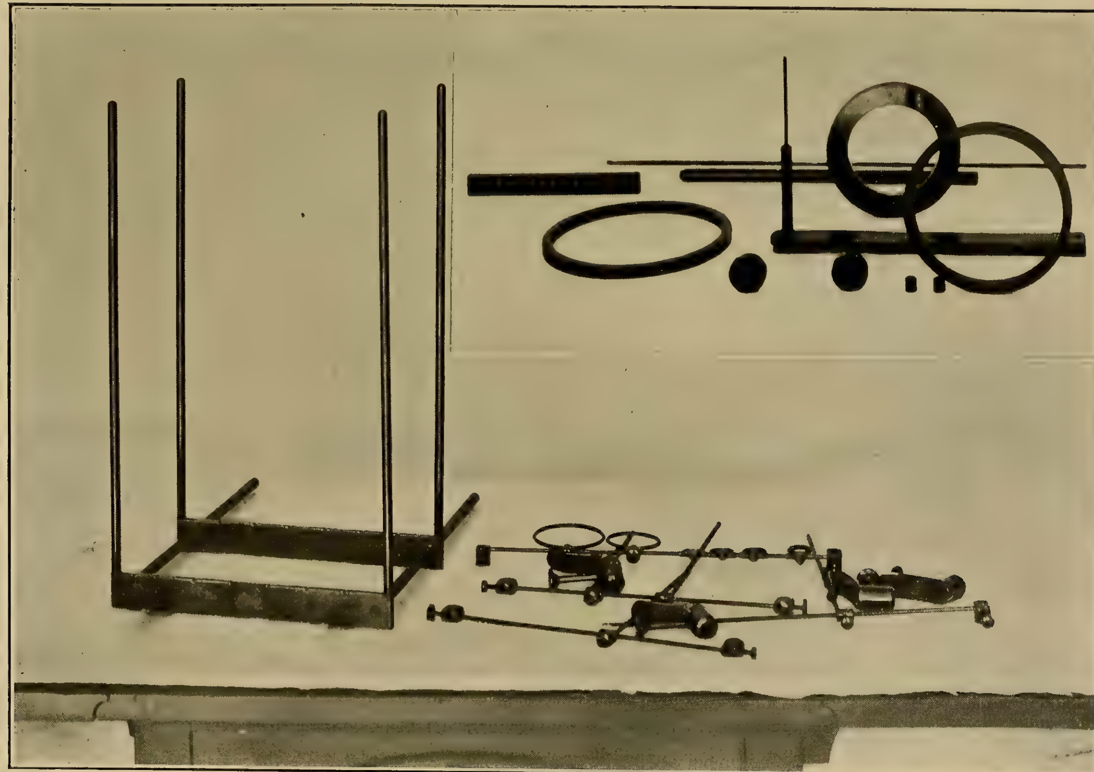


Plate 59.—Author's Examining Frame and Localizer and various Landmarks Useful in Radiography. This plate illustrates how the frame may be taken apart for ready adjustments of any markers selected. The rods and markers lie on the table at the right of the stripped posts. In the upper corner are separate landmarks. Magnify this plate with a fine reading-glass and the details of the pieces will be clearer.

PLATE 60.—This instruction plate shows Author's Frame and Localizer with a pair of rings substituted for rod markers to define a small field for examination. Also shows how frame can be tilted to any angle to engage axis of rays. Press the part to be examined close against ring on front and it will be in path of vertical rays.

Therefore a *direct localizer* which will work at sight with a single technic in but one plane comes near to filling a long-felt want in the profession. Such a device has not yet been adapted to the finer work on the eye so well accomplished by Davidson's method, but it can be used in many parts of the body, and, whenever it can be used at all, its advantages commend it to the surgeon. Such an instrument will now be described.

The Examining-Frame.—This practical little instrument, devised by the author in May, 1901, will be found of great service in many examinations with the fluoroscope, and has three uses:

1. It affords a practically instantaneous means of squaring the fluoroscope and tissues with the axis of the rays at any level and at a correct right angle. It establishes a correct field for the examination of a part, and a means of retaining it during all necessary movements of the examination. *Within this field, the anatomical relations are shown without distortion.* As an *examining-frame* it finds and fixes the field of observation and enables the operator to avoid divergence. The simplicity with which it does this must be seen to be appreciated. It also supports the fluoroscope by clamps.

2. As a *localizer* of a foreign body in parts accessible to the fluoroscope it does its work in about one minute, with but one posture of the part. It eliminates mathematics, cross-threads, and the radiograph from the localizing process. Both the level and *depth* of the object sought are shown with a single posture of the part, and the simplicity of the entire process commends it to both military and private practice.

3. When in position between the tube and tissues, and connected by a wire or chain to a gas-fixture or water-pipe in the office, it grounds electrostatic effects without any further complication.

The utility of the instrument in localization coincides with the capacity of the fluoroscope. It is especially convenient for the extremities and general work relating to parts of the body which the operator can manipulate as required in fluoroscopic examinations. Fine ophthalmic work so brilliantly accomplished with another localizer is beyond the scope of the author's apparatus, which is only designed as a simple and ready means of doing work that demands quickness and simplicity, leaving finer work to finer apparatus.

The instrument is intended for use upon (1) a standard, or (2) upon an examining-table. For the extremities and certain other parts a standard is especially convenient for the operator. Two hinges working at right angles permit movement of the frame through nearly a complete circle, either from side to side or antero-posteriorly. The telescoping rod of the standard permits it to be shifted to any height to suit the operator, who may sit or stand, as he prefers. A revolving post below the head permits a complete horizontal revolution of the frame. Set-screws adjust the parts as desired. The essential frame consists of two pairs of similar upright brass posts and cross pieces, adjustable to different distances from each other. A set of "markers" adjustable to all desired locations, and clamps to hold the fluoroscope, complete the device. The construction is too simple to call for further description beyond that shown by the photographs. (Plate No. 58.)

Directions for Use on a Standard.—1. Set the frame in front of the Crookes tube in the place that would be occupied by the subject in an ordinary fluoroscopic examination.

2. Close up the base and slide the markers together, so that they register as *one*, and then slide back the rear frame far enough to admit the part to be examined.

3. Level the frame to the height of the operator's eye.

4. With one eye closed, sight the focus of the anode and engage it in line with the *intersection of the markers.*

5. Clamp the fluoroscope on the front of the frame and insert the part to be examined.

So simple are these steps that they require no more than half a minute. We now have a definite field within which the axis of the rays traverses the tissues at right angles. The frame keeps this correct field constant before the eyes, with the rays perpendicular to the fixed plane of the fluoroscope, while the part to be examined may be shifted in the frame back and forth, up and down, and turned in all desired directions. As each area of the tissues is successively brought into the field defined by the markers the whole of an extremity can be examined with all distortion eliminated. Both hands of the examiner are free, as either a mounted screen or the fluoroscope is held securely in place. No particular preliminary posing of the tube is required. As all parts of the frame are both separately and collectively adjustable at any height, angle, or position, it can be sighted toward the focus of a tube situated anywhere, just as a rifle can be sighted at any target. *This independence of an exact position for the tube is a great convenience to the operator.* The actual setting of the adjustments of the markers in the frame is almost as simple as setting the hands of a watch, and can be almost as quickly done. Of course an object-lesson demonstrates this facility far better than can be told in print.

Directions for Use on an Examining-Table.—With the patient recumbent, examinations require that the frame be lifted from the

PLATE 61.—This instruction plate shows the Author's Examining Frame with its adjustable wooden floor used to level a part and support it during examination or localization. Turning the long spiral screws raises and lowers the upper shelf on which the part rests. Note the exact register of the two vertical guides in the axis of the rays. The central radiation coincides with the point where the horizontal and vertical guides intersect and the fracture, lesion, or bullet to be examined or located is seen without distortion when brought into this exact field. The plate teaches its technic at sight.

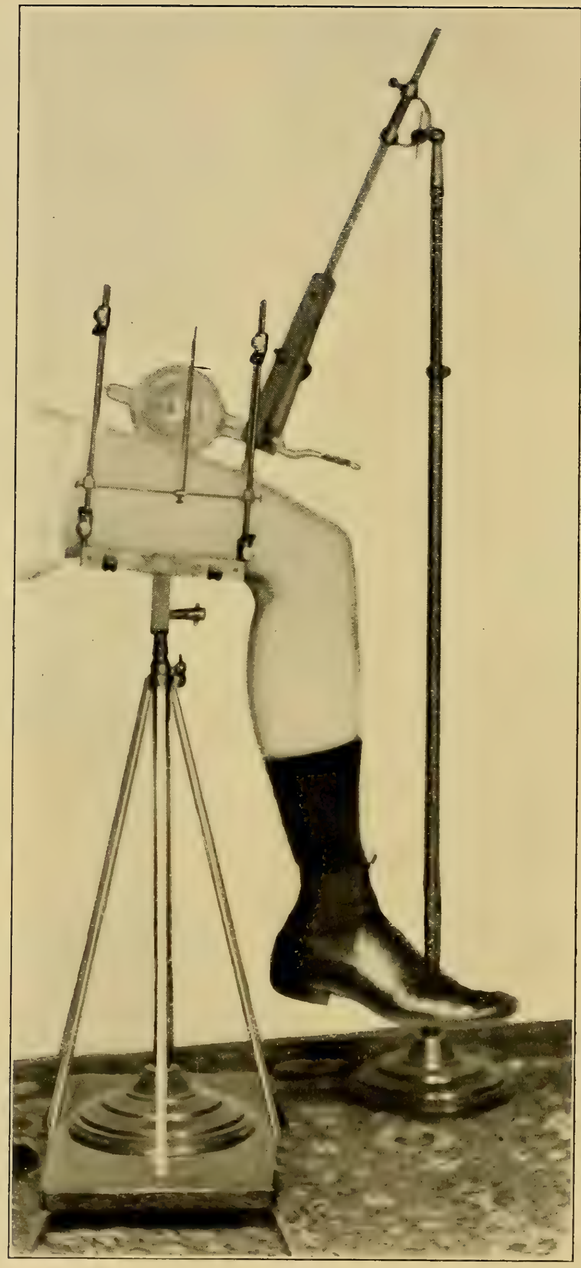


PLATE 62.—Author's Examining Frame and One-Minute Localizer, with middle of thigh in position for either simple examination or the simultaneous location of any lesion or foreign body. With the frame and part in this position sit in front of the frame, clamp the fluoroscope on the posts and inspect in the usual manner. Note that the frame holds the radial axis fixed and any part of the leg from the hip to the heel can be rapidly passed through the field of the non-distorted rays for successive examination. No other equally simple method exists.

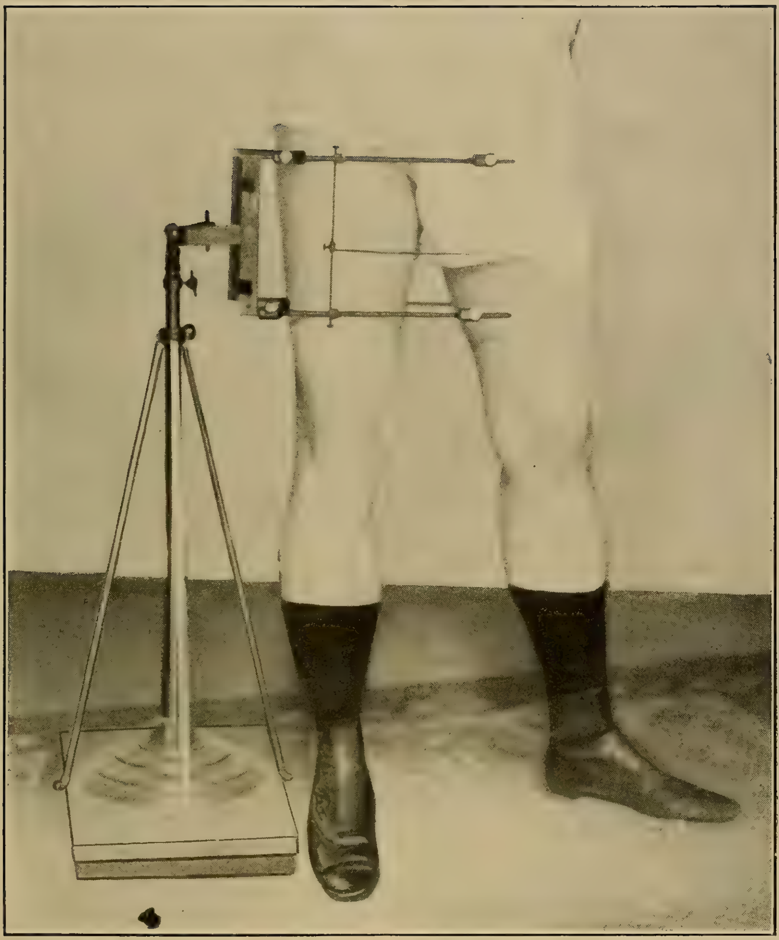


PLATE 63.—This instruction plate shows the Author's Examining Frame turned to side position to accommodate the thigh, or any part of the leg (or body), with the patient erect. As the frame has a universal series of joints it can be adapted to all positions in a moment. Examinations are a mere question of levelling the line of sight—swinging the frame into the axis of the tube in any desired situation—and then passing the part in view before the fluorescing screen in the field that is secured correctly by the markers. Study this important series of plates as a whole and in connection with the text and the general uses of the apparatus will be apparent.

Plate 64.—Author's One-Minute Localizer locating a bullet in the forearm with a single posturing of patient. Level the markers and tube as taught in the text, press the part on the front marker and screen, shift arm till bullet engages in angle of markers, then—(See next plate for second step).

standard and laid flat on the surface of the table. The adjustability of position formerly furnished by the standard and its hinged joints must now be supplied in one of three other ways:

1. A movable table-top, which can be tilted or partly revolved on a pivot will enable us to accommodate the frame to the focus of a tube in an ordinary independent tube-holder, in which the tube remains fixed where originally placed.

2. With the top of the table and frame both stationary, the focus of the tube may be accommodated to the examination by the tube-carrier, consisting of a bar attached to the opposite side of the table so as to permit the tube to slide along it, as in the Davidson apparatus.

3. An independent adjustable tube-carrier of great general utility for all examinations will be particularly useful in the present case and may be made as follows: Make a solid rectangular frame six feet high and two feet wide, grooved along inside upright posts to permit a small secondary frame to glide up and down within the large frame, as a window slides in its sash. Within the small frame construct a cross-bar tube-carrier. Have the main frame stand on legs or a base which will retain it securely wherever it is placed. Arrange a counterpoise weight which will suspend the frame holding the tube at any point desired. Arrange a set of pulleys and cords above and below the centre of the small frame, running to the top and bottom of the large frame so that sitting in his chair in front of the patient the operator can pull the tube-carrier up or down to any level required. Arrange a set of side cords which will pull the tube laterally across the horizontal-bar within the small frame. With this device for holding the tube the operator can then, without leaving his chair or taking his eyes from the fluoroscope, make the final small adjustments of the tube which will be required to bring the anode focus in line with the field markers of the examining-frame. When this is done, the method of making the examination is the same as before. Insert the part and fluoroscope and proceed.

Directions for Use as a Localizer.—Arrange the frame either on the standard or on a table, precisely as for any fluoroscopic examination, with the focus of the tube and the markers registering in line. Insert the wooden floor. Add the *depthing*-rod to the front right-hand post near the top. Insert the part containing the bullet. Lower the depthing-rod to contact with the surface of the part, and shift it to the extreme front of the frame against the fluoroscope.

With the tube lighted up and the fluoroscope finding the general situation of the bullet, quickly move the part till the bullet *engages the shadow of the vertical marking rods.* By means of the spiral screws, raise or lower the floor till the bullet reaches the *level* of the *horizontal marking rods.* It requires but an instant to thus engage it *at the point of intersection of the markers,* provided it is in a part which permits ready movement. In more difficult parts it will take a little more time.

Next turn the frame laterally on its pivot till the shadow of the bullet travels along the horizontal marker to a second upright rod about two inches to the left. Shift the depthing-rod *straight backward on its cross-bar,* till the shadow of its ball travels over to the marker pointing directly up from the shadow of the bullet. This completes the entire localization. *The bullet is as far in from the surface as the ball on the depthing-rod has been moved back from the front.*

The line of the *horizontal marker* gives the level of the bullet above the floor on which the part rests. Remove the fluoroscope, and with a dermal pencil mark a line on the skin parallel with these front and back horizontal markers, to record the cross-section wherein the bullet lies.

But how far *in* from the surface is the bullet? This is exactly indicated by the ball or pin on the *depthing*-rod. Its ball is exactly over the bullet in the exact line of the cross-section, and it has *found the depth* of the bullet without turning the part over or changing its posture in the slightest. In this respect the apparatus is unique.

The depthing-rod is provided with both a small ball and a short pin. The operator can use as an indicator whichever he prefers in a given case. Pressure of the pin on the tissues will make an accurate preliminary marking, which can be made permanent by nitrate of silver.

The localizer will perform its work in almost any position in which a part can be placed in it, and the operator may choose that which is most convenient. It is best adapted to the *cranium* and extremities. If a round bullet or object is localized very exactly, the ball of the depthing-rod will indicate the perpendicular of the *anterior surface* of the bullet. *The body of the bullet will lie behind the plane of this perpendicular.* If an elongated object is localized, the frame can be shifted to show the longest axis of pin, needle, bullet, or fragment of bone, and both ends and the connecting line between them can be mapped out automatically by the depthing-rod and the level finders. *No calculation or figuring at any time is required.*

In practice to become familiar with the device the beginner may bury small pieces of metal in irregular blocks of wood, odd shaped masses of bread, meat, or any convenient material. After making the shadow travel to the side post out of the direct axis of the rays,

PLATE 65.—Author's One-Minute Localizer. Second Step. With all parts held as before simply give the entire frame, with screen and arm, a slight lateral turn to either right or left. Stop when the bullet has travelled over to the vertical guide. With the right hand slide the *depthing rod* straight back on its guiding rod till its marking pin is exactly over the shadow of the bullet on the vertical guide. The bullet is located by this simple method without any divergence or distortion whatever and in a single moment. Hold the part still in the frame, unclamp the fluoroscope, mark the point of the front marker on the skin and mark the skin where the pin of the depthing rod touches it. When the two cross sections are thus marked the surgeon will find the bullet at the intersecting point without deviation. Study these plates in connection with the descriptive text.

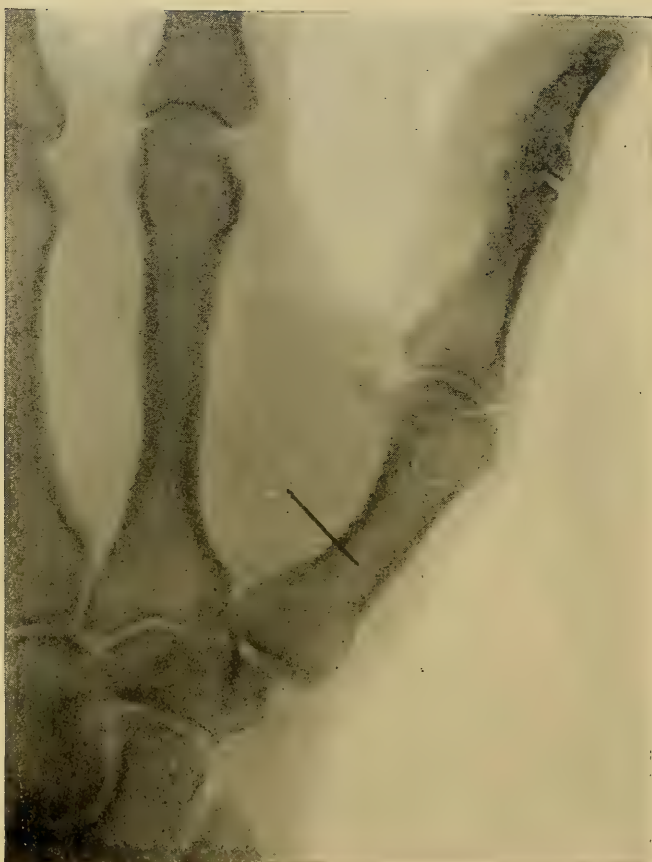


PLATE 66.—As an informal study in approximate localization observe that the fragment of needle in this picture has a sharp and apparently unmagnified shadow. It is therefore nearer the film than the bone.

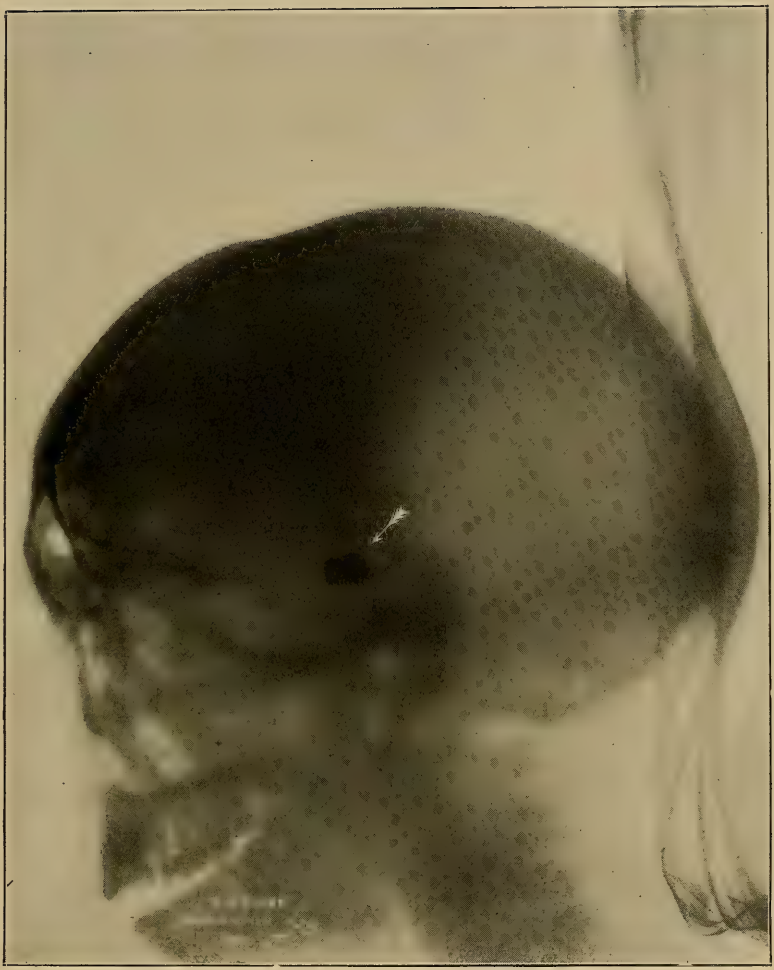


PLATE 67.—Arrow points to bullet located in skull underneath pons. Verified by operation and removal of bullet.

and shifting the depthing-rod, the operator may *prove* the accuracy of the adjustment by returning the frame to its original position; and if the ball on the depthing-rod is in line with the upright markers at the same time that the bullet is in line between the same markers on its lower level, it proves the result. The real facility of the *depthing-rod*, which is an absolutely unique device, can hardly be made plain till the student tries it himself. It works so simply that a child can understand it by a glance at the apparatus.

How to Readily Locate a Bullet in the Cranium.—By some of the methods described the localization of a bullet in the head may be considered so difficult that attention should be here called to the practical simplicity of the author's "One-Minute" Localizer in this particular emergency. It is doubtful if any other method so far known can compare with it in both accuracy and the quickness with which it can be done.

A lead bullet can be plainly seen in the cranium with the fluoroscope and any efficient modern apparatus. No radiograph is required. Proceed as follows: First view the head through the fluoroscope to see what position gives the best view of the bullet. Then shave the hair from the spot where the shadow falls on the screen. Next have the head held in the frame so that the shaved spot will rest against the front markers.

Engage the shadow of the bullet in the exact angle of the markers as taught. Then turn the frame and head together (as taught in the directions for localizing) and slide back the depthing marker till it indicates the *depth* of the bullet. Then shave the hair from the spot and again set the depthing-rod which was moved aside for the shaving. The exact localization is now complete. It has required scarcely more than a minute. To mark the scalp is the next need.

Cut two small round pieces of adhesive plaster one-fourth inch in diameter. Stick one on the scalp exactly under the marker of the depthing-rod. Remove the fluoroscope from the frame and stick the second piece of plaster on the scalp exactly in the marked angle of the rods in which the shadow was engaged. The bullet lies at the intersection of the two cross-lines marked.

Without any further "computation" or measurement the surgeon can readily judge how he will enter the skull to remove the bullet if an operation is decided on, or, having found where the bullet is, a decision to leave it *in situ* will be guided by known facts instead of guesswork. But in a very simple way exact measurements can be taken as follows:

After removing the patient and the fluoroscope (but with the markers and depthing-rod still left in position) lay one of the extra rods belonging to the set furnished with the frame across the markers so that it rest in the angle of intersection. Then either with calipers or a rule, or in any convenient way, measure the distance from the rod up to the ball on the depthing-rod. This gives the depth of the bullet below the scalp in inches and fractions. Then measure from the depthing-ball to the front marker, and this shows in inches the distance from the scalp to the bullet in the same direction. These measurements equal two sides of the square, and the other two sides can be measured in the same way if desired to complete the record. The actual simplicity of the only part of the technic that is really essential to the surgeon can perhaps not be fully realized from this word-teaching, but get out the frame and try it in practice, and the result will show its ease and readiness.

CHAPTER XXIV

METHODS OF LOCALIZATION

Studies in Principles and Technics. Triangulation. The Fluorometer. Localization without Plumb-lines or Threads. Ophthalmic Localization. Davidson's Thread Device. The Remy Localizer. Punktograph. Shenton's Method. An Emergency Case.

It is quite certain that the average surgical mind is more or less repelled by the formula and diagrams with which localization of foreign bodies or lesions in the tissues have often been presented in X-ray literature. And when, added to the difficulties of following the directions of a narrative writer, we find so many mistakes made in simple technics, it is small wonder that a clear mastery of the process has not been attempted by one surgeon in a hundred. Yet the matter is important when needed, and can be simplified. This we shall undertake to do in such a way that every student of this course can successfully apply a localization method to any case he may have in hand.

Back in 1896 the teachings were geometrical. The theory was one of simple "triangulation." Many jumped to the conclusion that two radiographs taken at right angles to each other, or two cross-sections observed with the fluoroscope and marked on the skin, would locate the object, and that the needle or bullet would be found by cutting down to the intersection of the two lines. It would be so found if the tube was in line, but unfortunately too many overlooked that simplest law of the projection of shadows from a point of light and failed to cut in the same direction that the light had been projected in. They worked out of the axis of the rays, and hence hundreds of errors were made and X-rays were called inaccurate, when the truth is that a straight line cannot deviate from accuracy. All it needs is to be aimed in the right direction. Then it will surely hit the mark. Working without regard to the line of the focus of rays, men sought to figure out the error of alignment and finally locate the bullet by a mathematical problem in triangulation. This insured scientific correctness, but was hard for physicians rusty on their algebra.

The technic was taught with scores of variations. For a needle in the hand cover half a plate with opaque lead. Place the hand on the other half, set the tube vertically over it, and make an exposure. Then shift the lead to the exposed half of the plate, put the hand on the fresh half, move the tube to an angle at one side and make a second picture. Then figure the angle of deflection. Many hastened to suggest improvements to this crude process. Merril taught:

"Place the plate on the table with the part containing the bullet over it. On the skin mark two sides of the plate. Place the tube over the side (not the centre) of the plate. Make the exposure. Drop a line from tube to skin and mark skin. Then remove patient, continue line to plate, and mark it with a pin prick on the film. Develop this negative.

"Place a second plate on the table with the part on it as before. Shift the tube a couple of inches. Drop plumb-line, measure and mark as before. Develop. Make prints. Lay the two prints with their reference edges together. Prick pin-holes through centre of bullet-shadow and plumb-line from tube. Take out the under print, and on its back there are now four pin-holes. These bear the same relation to each other that the shadows of the bullet and the lines of the rays in the two exposures have on the plane of the plate. Join these holes by two intersecting lines, and the point of their intersection will be perpendicularly below the plane of the bullet. Plot the triangles and figure out the result. To apply result to patient plot the measurements on the skin."

Two amplifications of this method were taught by the same author. The elaborate algebraic tables and calculations submitted by a score of teachers of early triangulation methods are here omitted. The mathematician does not need them, and others could not use them if they were cited. The simplest technic possible for working out the same principle without a localizing instrument is as follows: Centre the tube at twenty inches over the plate. Place the patient on the plate so that the bullet is over the centre of the plate. Slip a sheet of lead on the left half of the plate. Shift the tube three inches to the left of the centre and make the first exposure. Then shift tube three inches to right of centre, cover right half of plate with the lead, and make a second exposure with the patient unchanged. Then develop the plate. Then measure on the plate the distance between the centres of the right and left shadows of the bullet. Let us say it proves to be two inches. Multiply this by the distance of the tube (twenty inches). The product is forty. Also add the two inches between the shadows to the six inches the tube was moved parallel with the plate. The result is eight. Divide forty by eight and the bullet is the resulting five inches from the plate in a vertical line above the centre. When stated in algebraic formula with unknown measurements it looks complicated, and to make its real simplicity appear we have assumed distances in plain figures instead of $xy = \frac{AB \times CD}{Mn + AB}$

For fine measurements a centimetre or millimetre scale would be used, but we illustrate it in the more familiar inches in order to make it clearer to the beginner. The bullet will not be in a vertical line above the centre unless the technic is carried out exactly as here taught.

As some opprobrium has been cast upon X-rays and localizers in respect to needles which surgeons have failed to find in the place where they ought to be, after a careless X-ray observation by some inaccurate method, Scott makes the following suggestion: "Do not subject the patient to any delayed search. With the fluoroscope observe the needle again, and at the same time place the scalpel in the wound and you will instantly see the relation the knife bears to the foreign body. The further incision can then be definitely made."

Military Practice.—Of localization in the Spanish-American War of 1898 the special surgical detail of the Government reports:

"One thing this war has taught us is that the *probe* in all its forms *has gone out of use.* No more searching blindly in a man's body for the bullet; no more danger of blood poisoning from the introduction into the wound of instruments of search. The fluoroscope tells us instantly where the projectile has imbedded itself, and we have only to cut it out as if it were there before our eyes. *The ingenious electric probe and all similar devices have seen their day.* In all future battles experts in skiagraphy will be attached of necessity to the medical corps, and the work of the surgeons will be materially assisted by their precise indications. We took out bullets by the pint on board the Relief ship, and almost without exception they were located by the X-rays. It was all done in a few moments; five seconds for a wound in the hand; thirty seconds for a wound in the foot; not over ten or fifteen minutes for a wound through the thick pelvis. The patient is stretched out on a table, the X-ray tube adjusted over the wound, the plate put under the limb or part where the wound is, and the thing is done. The plates are developed almost immediately; in many cases we save *hours of vain searching;* not infrequently we save the soldier's life."

The Fluorometer.—The following description of this instrument and the photographs from which the cuts were made were prepared especially for this book by the courtesy of the Rochester Fluorometer Company. The most recent form of the apparatus is presented.

"The accompanying illustration and diagrams show the practical application of the simplified form of the Dennis Fluorometer in its use in utilizing the Roentgen rays for surgical and medico-legal purposes.

" As shown in the illustrations the appliance consists of a suitable frame work, a thin horizontal metallic-bar, two adjustable thin vertical bars with movable sights or pins, a metallic screen or grating with appropriate standard for maintaining it in position, and to serve as a plate-holder when the desired position is obtained.

" In the present state of advancement of the art all X-ray operators are familiar with the distortions in the shadow caused by the divergence of the X-rays. The function of the Dennis Fluorometer is to eliminate this distortion and to produce accurate results, both on the fluoroscopic screen and the sensitive plate (as shown in plate 71). In other words, to provide the surgeon or medico-legal expert with data upon which to base positive and unerring diagnosis. It is so constructed as to apply equally to all parts of the human anatomy.

" For the purposes of this description a case of a bullet in the human wrist is selected as shown in the plate. The wrist is placed with the palm of the hand downward between the two vertical bars of the instrument. Observing now with the fluoroscope, the tube is so adjusted that the two vertical bars show a single shadow on the fluoroscopic screen. The limb is then moved until the shadow of the bullet coincides with the single shadow of the vertical bars. It will be seen at once that if the limb should be amputated at the point indicated by the two vertical bars, the bullet will be encountered on this cross-section, and its position vertically above the horizontal-bar will be indicated to the observer on the fluoroscope by the meshes on the metallic screen. See Plate No. 72.

" Just here two movable pins or sights on the arms of the Fluorometer appliance come into use. These pins are placed equidistant from the base of the Fluorometer (which is, of course, squared with the frame). Then when the frame with its patient is adjusted so that the pins or " sights " coincide with the foreign object it will be seen that all three are coincident, and that the characteristic distortion caused by the angle of the rays has been eliminated (as shown in diagram A). Measurements, taken with the eye by means of the metallic grating, will thus enable the surgeon to discover unerringly the position of the object with reference to the surface of the limb which contains it.

" How far *in* from the surface of the body it may be, however, is, at this point, still unsolved. (See diagrams in Plate No. 73.)

" Marking the wrist between the vertical arms of the Fluorometer for convenience, and also marking the points indicated by the pins or sights, the limb still maintaining the same cross-section is given a quarter turn as shown in plate 72. The pins are again adjusted as before, establishing a new line through the bullet and the cross-section of the wrist as shown in diagram B. The position of the pins having been again marked, it will be found that the bullet is situated at the intersection of the two right lines as indicated in diagram C.

" The method of adjusting the pins or sight referred to is such

PLATE 70.—Primitive Localization. A method of localizing a bullet. This case is inserted to illustrate the phases of the growth of modern scientific localization. Says the surgeon: "The patient, a man aged twenty-one, came to the hospital three months ago with bullet in hand; hand much swollen and very painful. Took an ordinary radiograph, which plainly showed the bullet in the palm apparently resting on the bones of the carpus.

"With this picture before me I cut down to the bone, but even after prolonged search failed to find the bullet. I tried several experiments in localization by making lines on the hand with various paints of lead, mercury, and bismuth. All of these were photographed on a plate more or less distinctly, but did not show lines definite enough for the purpose. It then occurred to me to have a grid made of iron-wire as shown in photograph B. This was painted on one side with an aniline dye and fixed to the palm. The palm with the grid in situ was then placed on the sensitive plate, a layer of celluloid being interposed to keep the dye from the plate. The result was that the hand and the photograph were both marked by the grid. I then cut down a second time into the palm, and being quite sure that the bullet must be under the knife went further than before and found it wedged in firmly between the os magnum and trapezoid bones and nearer to the back than to the palm of the hand. I have since had a fine and flexible grid made which adapts itself to the part." (Rebman, Ltd.)

The defects of a method once deemed ingenious but now known to be far from true localization will be better understood by the reader after making for himself the tests suggested in our chapter on distortion. Many of the early complaints that bullets were not where the rays showed (?) them to be arose chiefly from the failure of the operator to place his tube so that the focus of the rays, the bullet, and the centre of the photographic plate would fall in a straight line perpendicular to the plane of the plate. This is easily done, but at first and even now, it is ignored by many. Compare with the Author's "One-Minute Localizer."

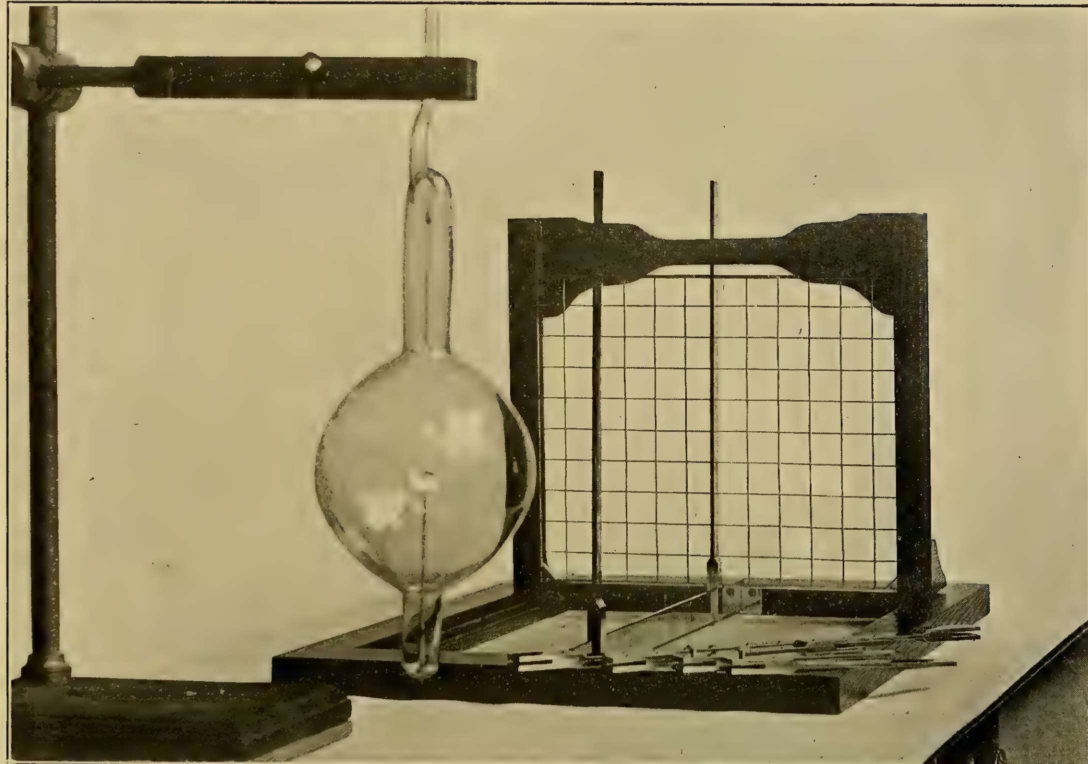


PLATE 71.—The New Fluorometer. Set up screen, bars, and tube as shown in this plate. Align the focus of the tube so that the bars cast one shadow on the fluoroscope. Insert the part to be examined as taught in the next Instruction Plate.

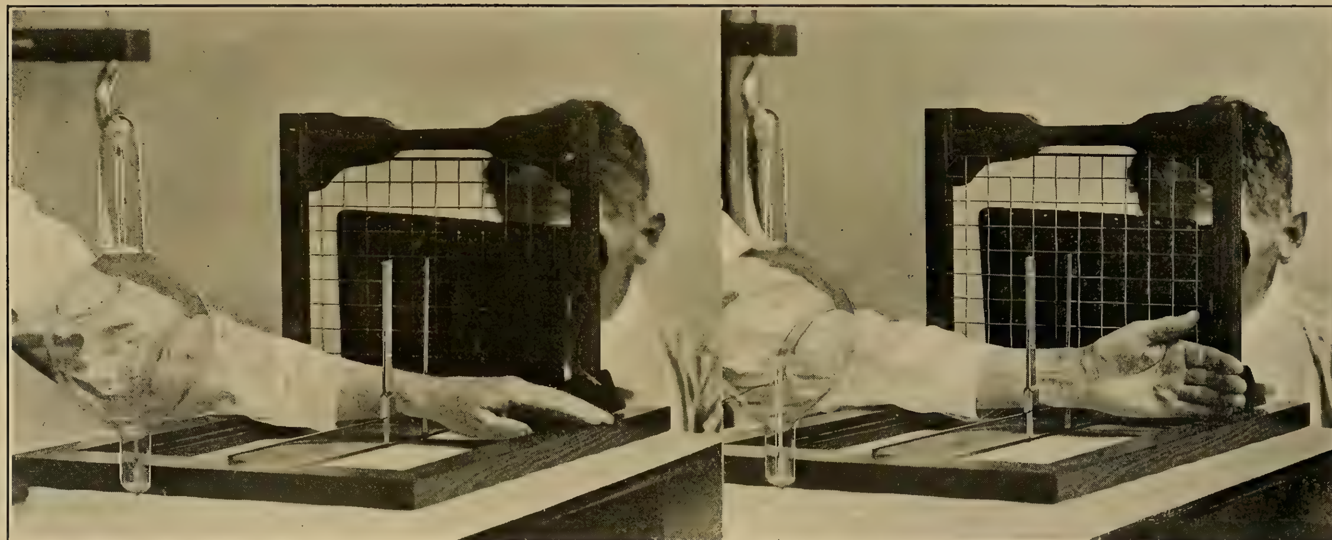


PLATE 72.—Locating a bullet near the wrist with the new Fluorometer. First mark the level of the shadow with the arm in position as shown at the left. Then make a quarter turn and mark the second cross-section. The next plate shows the result in diagram. The arm is here illustrated for simplicity, but the principle is the same in all parts of the body accessible to the fluoroscope. These plates are from advance photographs of the new model made especially for this work by the courtesy of the Rochester Fluorometer Company.

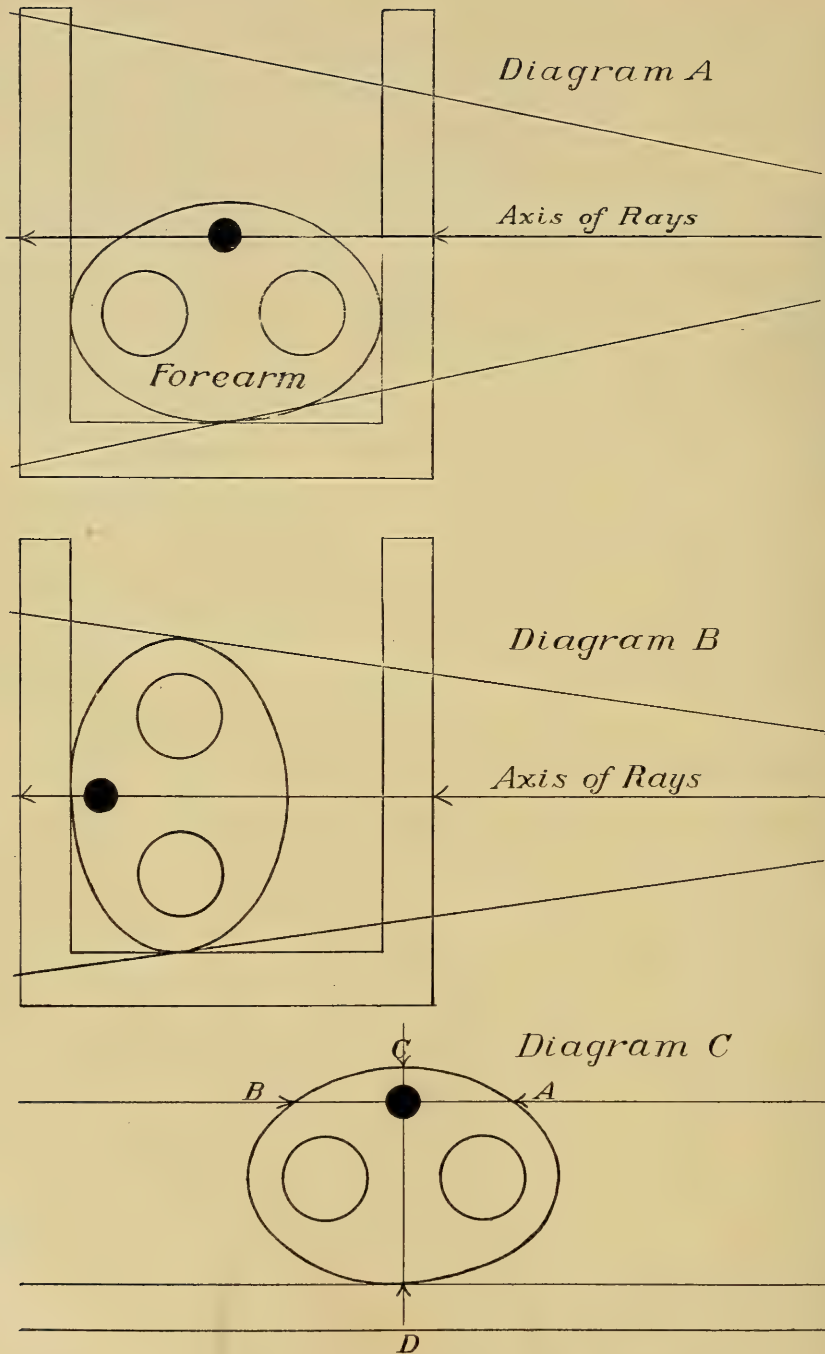


Plate 73.—This diagram teaches the exact findings of the fluorometer when used as taught in the preceding plates and text.

that when the final observation is taken by means of the fluoroscope a light line intersecting the two sights and the centre of the bullet observed will be exactly parallel with the base of the instrument in each observation. Hence, by glancing at diagram C, it will be seen that the line AB secured by the first observation will intersect the line CD secured by the second observation at the centre of the bullet, thus unerringly indicating the position of the bullet on the cross-section of the wrist as shown by the markings on the surface.

"It will also be seen that, after the proper position has once been obtained, its undistorted record may be preserved by placing a sensitive plate in the upright plate and screen-holder. Medico-legal experts will thus be enabled to procure an undistorted radiographic view of any portion of the human anatomy, and can by means of the Dennis Fluorometer reproduce the position and its radiographic record at any time they may desire to do so.

"As shown above, the diagnosis produced by the Dennis Fluorometer will disclose to the surgeon unerringly the location of any foreign object, or the condition of dislocation or fracture. The instrument is the invention of John Dennis, Rochester, N. Y."

Localization by a Double-Focus Tube.—A paper entitled "A double-focus tube for the accurate localization of foreign bodies by the fluoroscope or photographic plate" was presented in November, 1899, by Leonard. In it he says:

"The technics required for triangulation methods seem to have been a barrier to their general employment, and to simplify the application of the same principles the author has had made a tube with two cathodes and two anodes, and hence two sources of rectilinear rays. This avoids the errors that creep in when the position of the tube has to be changed or separate plates used, and it has made rapid accurate localization with the fluoroscope easy. By it we can also avoid the delays necessitated by the development and fixation of a negative. The fluoroscopic method is as follows:

"Fix the screen in a perpendicular position. Place the tube horizontally so that the mid-point of the line connecting the two sources of rays is perpendicular to the plane of the screen, and at a known distance from the centre of the screen marked by an opaque cross. This is all the adjustment required, and can be readily made in a square. Place the limb containing the foreign body before the screen so that the two shadows of the bullet will fall equally distant on each side of the opaque spot and on the same line. The foreign body is on the line perpendicular to the plane of the screen at the opaque point. Mark the spot on the patient's skin with nitrate of silver.

"By placing an opaque rod on the other side of the limb, where its two shadows are equidistant from the opaque spot, the perpendicular is found and marked on that side. The foreign body, therefore, lies on this line at a distance from the opaque spot that is determined by measuring the distance between the two shadows of the foreign body with calipers and plotting the shadowy paths by the graphic process as when plates are employed, or by the cross-thread method."

Professor Barrell's Method of Localization without Plumb-Lines or Threads.—" In all methods of localizing the position of a foreign body it is essential that two distinct skiagrams should be taken, though it is convenient often to have the two pictures superimposed on the same plate. As is well known the position of the tube must be changed between the taking of the first and second picture, and the distance which the focus has moved must be known. Further, it is essential to know the points on the plate where it is met by lines drawn perpendicular to it from the focus. In all existing methods of localizing the position of these points is ascertained by use of the plumb-line, and in order to secure any accuracy in the results *the plate must be levelled* before the pictures are taken. The use of plumb-lines is at all times fussy and annoying, and is especially so when the point from which the plumb-line *ought* to be suspended is an invisible 'focus' situated somewhere in the middle of the glass bulb.

" Having mastered the difficulty of the plumb-line there also remains in most methods the further trouble of stretching two fine threads, and measuring the position of the point where they cross each other.

" My method requires no *plumb-line*, no *threads*, and no *levelling*. My apparatus consists of two metal cylinders whose ends have been carefully turned perpendicular to their axes. A convenient size is four inches by one inch in diameter. Place these cylinders upright on the plate during an exposure and close to the limb which contains the foreign body. The shadows thrown by the cylinders indicate the position of the focus of the tubes. To secure a good long shadow, place the cylinders near the end of the plate farthest from the tube. After the first exposure shift the tube six or ten inches. Then shift the cylinders toward the opposite end of the plate and make the second exposure." (See Plates No. 74 and 75.)

Sweet's method of localizing a foreign body in the eye has been taught as follows: (See Plate No. 76.)

" For this purpose an indicating apparatus is used carrying two steel rods each with a rounded end. The indicators may be supported by a head band, and the plate held to the side of the head by an ordinary bandage. The balls of the indicator are at a known distance apart, one pointing to the centre of the cornea, and at a known distance from the eye-ball, while the other is parallel to the first, toward the external canthus. The visual line is parallel to the indicators and to the plate. The ball should also be perpendicular to the plate. In making the negatives the tube is in front, about thirteen inches from the plate, and at an angle of from fifteen to forty degrees, with a vertical plane passing through the apex of each cornea. The plate is at the opposite side of the head, and the rays pass through the eye-ball and the external orbital-wall before reaching the film. Two exposures are made, one with the tube in a horizontal plane, or nearly so with the two indicators, and the second at any distance below. The angle of the tube below the horizontal is unimportant so long as two exposures give different relations of the indicators on the negatives.

" In determining the position of the foreign body in the eye, two circles, twenty-four millimetres in diameter, equivalent to the size of the globe are drawn upon paper. One circle represents a horizontal section of the eye-ball and the other a vertical section. Upon the vertical section a spot is marked at the centre of the circle indicating the position of the centre indicator of the apparatus. The distance between the two indicators is measured toward the temporal side, and a spot made to show the position of the external indicator.

" On the circle representing a horizontal section of the eye-ball a spot is made anterior to the centre of the cornea, and at the same distance that the centre indicator was from the eye when the radiograph was made. Another spot to the temporal side, measured by the distance between the two balls of the apparatus, marks the situation of the external indicator. Taking the first negative with a tube nearly horizontal to the two indicators, measure the distance of the foreign body below to the two balls of the apparatus. These measurements are indicated on the circle representing the vertical section of the eye, and a line is drawn through the point. Somewhere along this line is situated the foreign body.

" From the second negative, made with the tube below the plane of the two indicators, the measurement is taken of the distance. The shadow of the foreign body is below the centre indicator, and this point is indicated in the first circle. The distance the foreign body is above the external indicator is measured, and the point indicated on the circle. Where a line drawn through these points crosses the line of measurements made from the first plate is the situation of the foreign body as respects its horizontal and vertical position in the eye-ball.

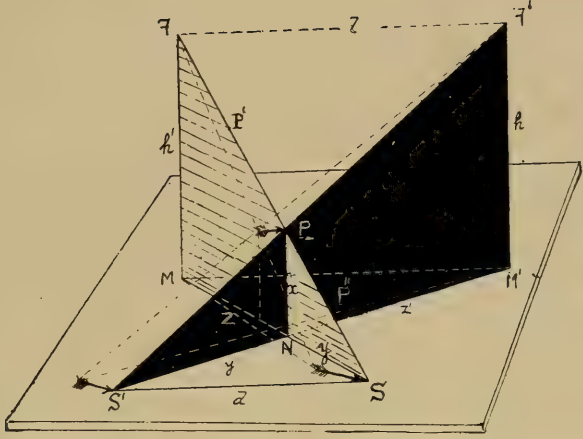
" To determine the distance of the foreign body behind the apex of the cornea, the negative made with the tube nearly horizontal is taken and a measurement made of the distance the shadow of the centre wall is posterior to that of the external ball. The distance is entered directly above the external wall on the diagram representing the horizontal section of the eye. From this point a line is drawn through the ball of the centre indicator, which indicates the direction of the rays from the tube when the exposure was made. Taking the negative again, we measure the distance that the shadow of the foreign body is from that of the external indicator. The distance is marked perpendicularly to the spot representing the ball of the external indicator on the diagram, and a line is drawn parallel to the direction of the rays from the tube. Where this line cuts a line perpendicular to the position of the foreign body shown on the vertical section of the eye-ball is the distance of the foreign body behind the anterior portion of the cornea.

"In working out the position of the foreign body certain factors are essential; a tube should be used of high efficiency in order that the rays may readily penetrate the bones of the head with a short exposure. The patient should be in a position to insure absolute steadiness of head and body. The visual axis should be parallel with the plane of the plate at the side of the head. The situation of the indicating objects with respect to the centre of the cornea must be known factors. The angle of the tube with the indicating objects must be accurately measured."

Davidson's Localizing Apparatus.—Modifications of this apparatus are portable and less expensive than the original, which perhaps reaches the high-water mark of scientific accuracy and universality of application in the hands of an expert. A complete equipment of the localizer, the tube-carrier, and the head-rest for eye work was brought by the author from London in 1898. The description of the originator is as follows: (See Plate No. 77.)

"The extended use of the X-rays has led to an increasing need for some simple method of localization which can be at once readily carried out, and at the same time be reliable. The method I have devised is of this character. It was, of course, obvious from the first that taking the skiagraph from two or more points of view was a necessary starting point to any method of localization. But the question of *how the resulting photographs were to be dealt with to give the desired information* remained a difficulty, except to the comparatively few who were sufficiently familiar with geometrical drawings and mathematics. My method is as follows: I take two skiagraphs from two different points of view. In order to carry out the adjustment and movement of the Crookes tube I use *a horizontal bar with a scale upon the front of it graduated in millimetres* with zero at the *middle point* of the bar. This bar slides up and down upon two brass rods which rest upon the floor on a base like a standard lamp. The bar can be readily detached at one end and opened like a gate to facilitate the placing of the patient. A small holder carrying the Crookes tube slides horizontally along the bar, and there are two stop-pieces with set-screws which permit the tube to be quickly moved and accurately fixed from any position on one side of zero to the same position on the other side.

"To adjust the Crookes tube to a particular height is a small bar applied vertically carrying the tube up and down with it and acting as a *fine* adjustment. It is fixed with a set-screw. A small spirit-level is inserted on the top of the cross-bar. This part of the apparatus is simply a convenient method for shifting the tube in taking the two skiagraphs, and somewhat similar arrangements have been used before.



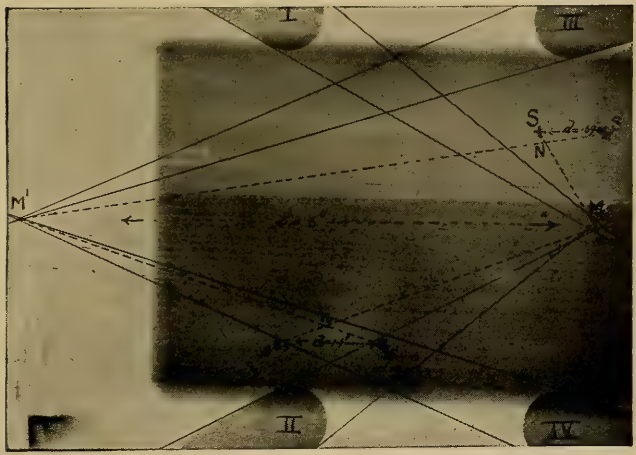


PLATE 74 (1) and (2).—Illustrating "A New Method of Localization without Plumb-lines or Threads," by Professor Barrel. See text for description.

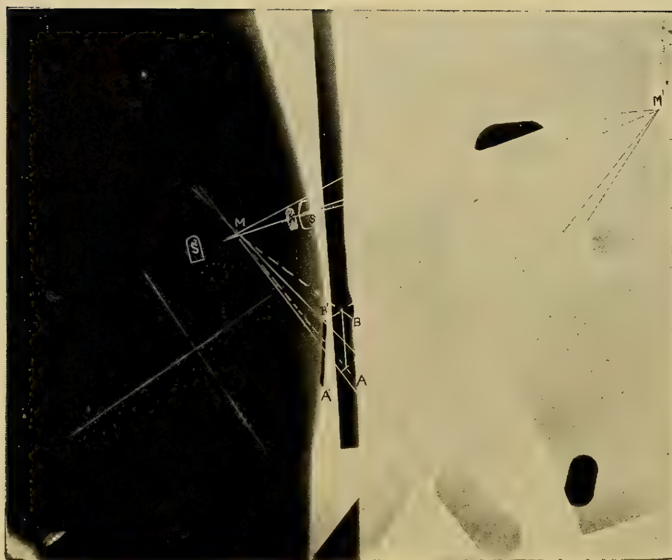


PLATE 75.—Bullet Located by Mr. Barrel's Method. Three distinct indices were fixed to the patient. The first was a small cross of tin-foil, which is readily visible in the negative, but can only be detected in the print by the white cross rising from the lines by which it was marked out. No use was made of this index. The third index, the only one used, was a narrow strip of lead fixed between two prominent marks left by the stitches near the outer part of the gluteal fold. The patient lay on his back so as to about half cover a 10 x 12 plate, leaving plenty of space on which to stand the localizing cylinders. Two exposures on the same plate were made, each three minutes, with electrolytic interrupter. The position of the bullet having been ascertained the patient was made to again lay on his back on a drawing-board. A mark was made on the skin at the indicated height, and the position of the bullet located. (Rebman, Ltd.)

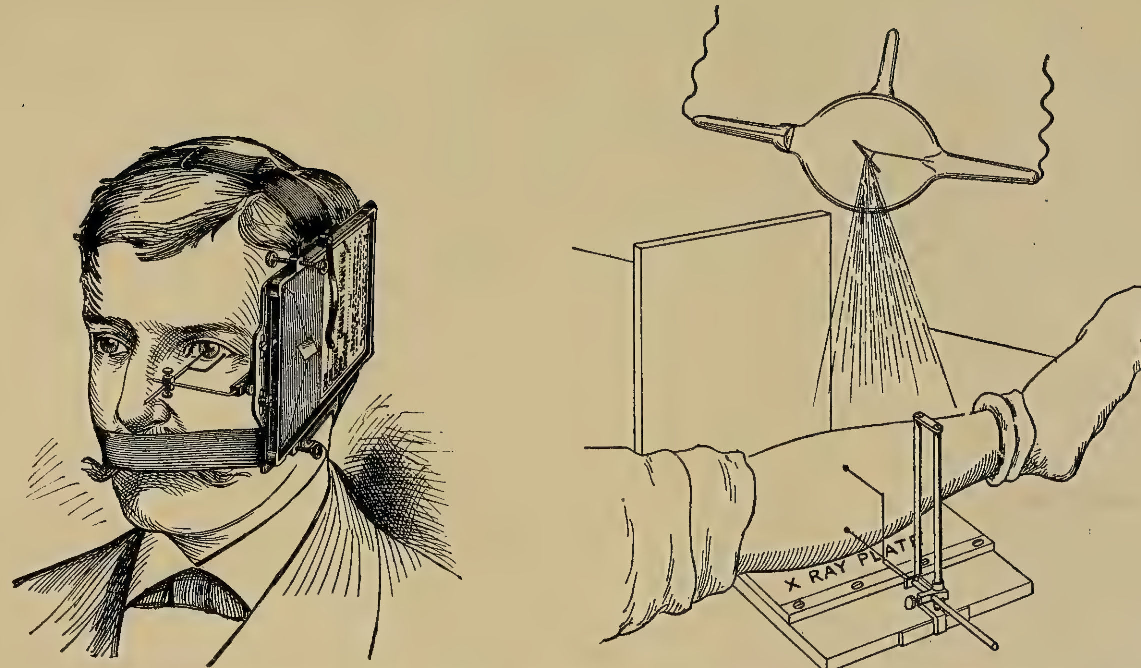


PLATE 76.—Method of arranging this form of localizer upon the side of the patient's head for foreign body in the eye, and also showing one method of similarly localizing a bullet in the leg. The principle is made clear by the illustration.

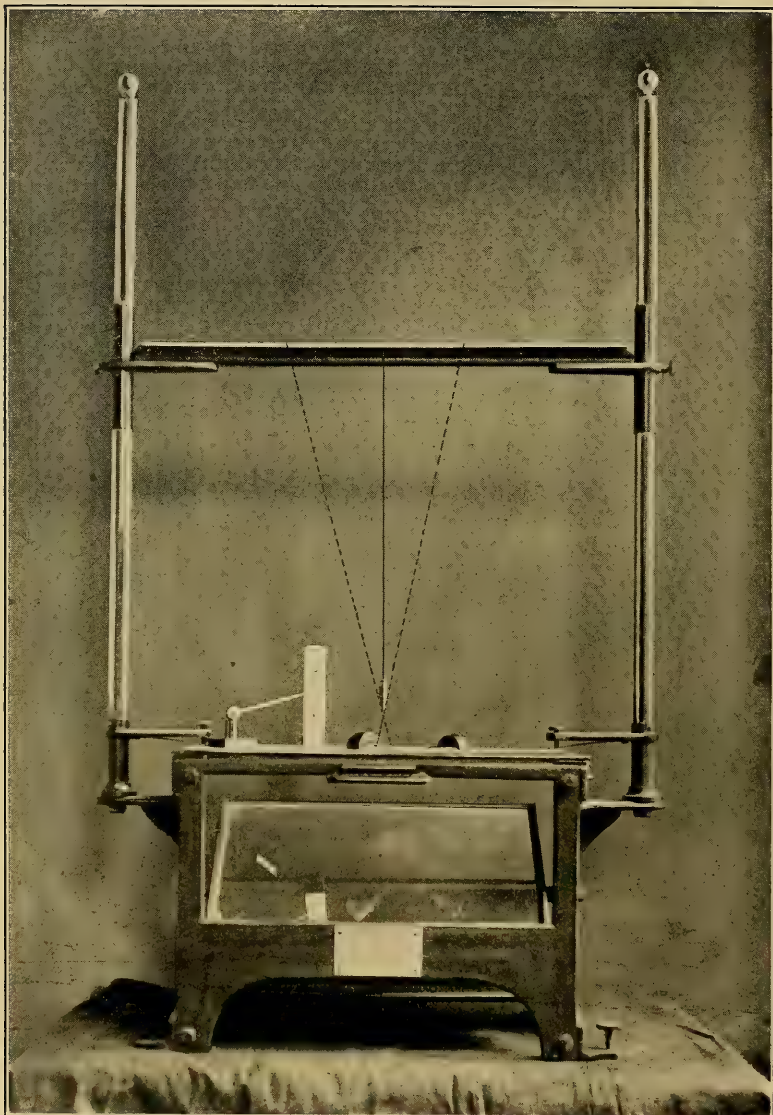


PLATE 77.—Author's duplicate of the original Mackensie-Davidson Cross-Thread Localizer. The mirror below reflects up the light through the negative on the levelled glass plate. The pointer and vertical scale are seen on the left. The mouse-shaped weights end in needles holding the threads. The cross-bar with its millimetre scale can be set at any distance from the base and must be the distance from anode to film when the negative was made. The plumb line suspends a lead pointer at a height above the plate. The dotted lines, equidistant from the centre, start from the two foci of X-rays in the exposure. They cross at the end of the plummet and end at the two shadows on the negative. Simply measure the distance from the plate to the crossing of the threads, and we have the depth of the body from the surface of the tissues that was on the film of the radiograph. First make a proper double radiograph and the rest is simple. See full directions in text.

"*Method of taking the skiagraph.*—Place the tube in the sliding holder. Place the sliding holder with one of its edges on *zero* in the centre of the horizontal bar. Adjust the two check-clips three centimetres to the right and left of zero. On the operating-table below the tube place the plate-holder and then drop a small plumb-line *perpendicularly from the focus-point of the anode.* Then move the plate-holder so that the *centre* where two wires cross and divide the plate into four quadrants *is exactly under the plummet-point.* Also sight it over the edge of the horizontal bar and lay the plate so that the *horizontal wire exactly agrees with the horizontal bar.* Next adjust the tube at the desired height. Make an exact measurement of the distance between the surface of the film and the exact surface of the anode, as any variation in recording this distance will affect the results. Now move the tube-holder till it meets a check-clip on one side of the centre. Brush the cross-wires over the plate-holder with marking ink and bring in and insert the plate under the cross-wires. Now place the part of the patient to be photographed in position on the plate and lay a small metallic object on one of the corners of the plate to identify the quadrant. Switch in the current and make the exposure as usual.

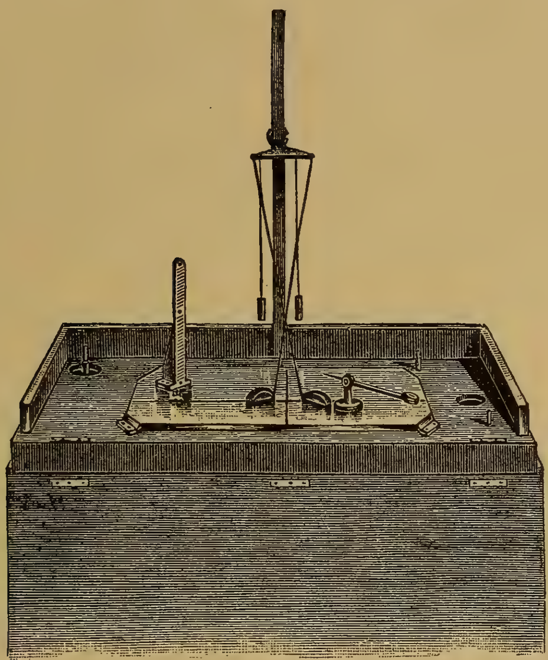


Fig. 15.—A modification of the cross-thread device for readily finding the depth of any foreign body in the tissues after making the preliminary double radiograph. It is designed for portability. See Plate No. 76 for picture of the finer original apparatus.

"At the end of the first exposure cut off the current and slip the tube-holder over to the opposite check-clip, a lateral displacement of six centimetres from the first position. Then make a second similar exposure *on the same plate* and without the patient moving. At the end of this exposure develop the negative in the usual way, and it will contain two shadows of each body opaque to the X-rays. The patient will be marked by the cross-wires on the lower surface of the skin, and with ink I also mark the quadrant on which the metallic marker was placed. It is also an advantage after the part is in position for exposure to again drop the plumb-line from the tube and *mark the centre on the upper surface of the skin.* By dropping the plummet from zero and from each of the check-clips and marking the line on the skin crossed by another line at right angles from the centre it will mark the *upper* surface to correspond to the cross-wire marking *below.*

"By means of the above data the position of the foreign body can be worked out by a mathematical formula, but as everybody does not recall his mathematics easily I have devised a method of dealing with the result which is accurate and within the reach of every one who can use a foot-rule and a pair of compasses.

"The *localizer* resembles a photographer's *retouching desk.* Upon an iron stand a piece of plate-glass is placed horizontally, with a spirit-level. Below is a mirror which can be adjusted to reflect up the light from a window or a lamp. Above, a horizontal bar slides up and down on two vertical brass rods. On the cross-bar is a millimetre scale with a small notch at each millimetre mark, and *zero* is in the centre. On the glass plate are cut two lines at right angles to each other, *marking the plate as the cross-wires mark the negative.*

"This glass plate (which is movable) is so placed that the point where the lines cross is vertically beneath the *zero on the scale above,* and the line on the glass running right and left as the operator faces the scale is placed *parallel to the edge of the scale.* The scale is now raised or lowered so as to make zero on it *precisely the same height above the negative as the distance between the anode and the film when the negative was exposed.* With a slight washing after fixing the negative can be at once placed upon the horizontal plate of the localizer and easily adjusted so that the lines produced by the cross wires *register with the lines cut in the glass plate, and the marked quadrant is in the same relative position as it occupied in the exposure.* As a routine practice I always mark the upper *right* quadrant as I stand facing the scale on the bar. To protect the wet gelatine surface of the negative, I place a sheet of very thin mica or celluloid over it. If it be a film, I place it face downward and squeegee it. It thus remains fixed and the celluloid is so thin that the thickness may be ignored in the subsequent measurements, but it is important to remember that if the negative is placed with the *gelatine surface downward* the relations of the parts are *reversed.*"

"The *negative* is thus placed under exactly same conditions as existed when it was taken, and all that is now required is to trace the path of the X-rays which produced the negative. I do this in a very simple way. With the apparatus are two white silk threads with a small weight on one end and the other threaded into a fine needle which is fixed into a piece of lead shaped like a mouse.

"Place one of these threads in the notch as many centimetres to the right side of zero as the tube was *displaced* to the right during the exposure. Place the other thread in the corresponding notch on the left of the centre. Run these two threads down to the film and let the eye of each needle rest on the point of the *shadow* of the foreign body made by the corresponding focus of the tube. *These two threads then reproduce the path of the X-rays.*

"First measure the vertical distance from the negative to where the threads cross each other by means of an ordinary pair of dividers. This is the depth of the point of the needle *beneath the skin of the patient* which rested on the photographic plate, assuming that we are now locating a needle in the arm. A surface gauge is furnished for easily making this measurement. Next measure the vertical distances from the shadows of the cross-wires to the points where the threads cross. An upright square belonging to the apparatus is placed with its edge coincident with the shadow of one of the wires, and the perpendicular distance from it to the point where the threads intersect is measured with compasses. We now note down the result as shown in figure.

"We then ascertain the position of the eye of the needle in a similar manner, and the distance between the two points when connected by a line gives *the direction and actual length* of the needle in the tissues. From the measurements jotted down we can mark on the patient's skin a line in the same plane as the needle and give the surgeon the exact depth at which each of the extremities can be reached by a vertical cut. A final result of the process is that you can draw an outline of the foreign body of the patient's skin, and give the depth below the skin of any of its parts. While lengthy in description, it is rapid and reliable in practice, and can be done very quickly after a few trials. Triangulation automatically by means of these threads and this scale device is capable of wide application. It will also prove useful in the measurement of bones, displacements, and especially in pelvic measurements. Provided two fairly well-defined double skiagraphs, preferably on the same plate, can be obtained, the measurements cannot fail to be accurate."

The most remarkable results in exact localization with this apparatus have been obtained with foreign bodies in the eye. Nearly a year ago Davidson had a record of more than 250 eye cases, and so accurate are his results that a particle of steel of the smallest size in any part of the eye-ball can be cut down upon and extracted with the precision and certainty of sight. In respect to eye work, at least, Davidson's technique outclasses all rivalry in this field, and, having personally witnessed his work, the author can vouch for its simplicity and success.

Most of the difficulty of localizing with this almost automatic device will result from first making the negative *without regard to the situation* of the bullet or other foreign body. If the exposure is made with the bullet *aligned* in the axis of the rays it will be right over its shadow on the plate, and the *depth* will be *the distance from the film to the crossing of the threads.* In regular use the cross-bars of the exposing-table and the localizer can be kept in permanent adjustment to correspond, and then the mere placing of the leaded ends of the threads on the shadows on the plate will automatically show the depth at once. No figuring is required, and the distance between the cross-point and the film is noted by a pair of dividers. Fine work within the eye will require special training, but apparently all general parts of the body present a minimum of difficulties to this classical method. Make the first steps of the process correctly, and the rest will easily follow.

The Remy Localizer.—The localizing apparatus of Dr. Remy can be used with either the fluoroscope or negative, and weighs but a few pounds. It is constructed entirely of metal, and when taken apart is carried easily in a box about 7 × 18 inches in size. An open screen is required, as the box of the regular fluoroscope interferes. It takes the principle of two crossing rays, and, instead of threads, it represents the two paths of the shadow by two metallic rods, which show the depth of the bullet by converging and meeting. The depth the rods are moved down the frame before their points meet equals the depth of the bullet in the tissues. The use of this device is illustrated in Instruction Plates No. 78 to 83 inclusive. The author's description is as follows: *

" Suppose a rectangular plane. Assume that the upper edge of the rectangle intersects two foci producing X-rays. The rays from one focus cross those proceeding from the other; but it is always possible to determine to which tube any one of the rays belongs, whatever may be the point in the plane at which we place ourself.

" Let us now neglect all that part of the plane touching the tubes; the direction of the rays will then be represented only by lines of a few centimetres in length, but by prolonging these lines we will reach the centre of each of the foci. Let us now interpose between the tubes and the remaining part of the plane a fluoroscent screen, and interpose an opaque body to the X-rays, the shadow of which is thrown on the luminous screen. If the foreign body is in this plane, its shadow will

* Archives of the Roentgen Ray.

PLATE 78.—The Remy Localizer. First position. With the first tube below throwing the shadow of the object on the screen seen on the chest of this patient push down the first rod in the axis of the rays till its point marks the centre of the shadow. This rod then resembles one of the threads in the more familiar "cross-thread" localizer.

PLATE 79.—Remy Localizer. Second position. Move the tube horizontally to the focus for the second shadow on the screen and push down the second rod to meet the centre of this shadow. The two rods then are the equivalent of the axis of the rays from the two foci.

PLATE 80.—Remy Localizer. Third step. Having the two rods converging on the two shadows, remove the screen and push down the rods till they touch the skin. If they were now carried into the tissues till their converging points met the bullet would be at that situation, exactly as it is at the point of intersection of the cross-threads in the Davidson apparatus. The principle of both is the same, though Remy uses rods beyond the field of the rays, and Davidson uses threads within the field of the rays.

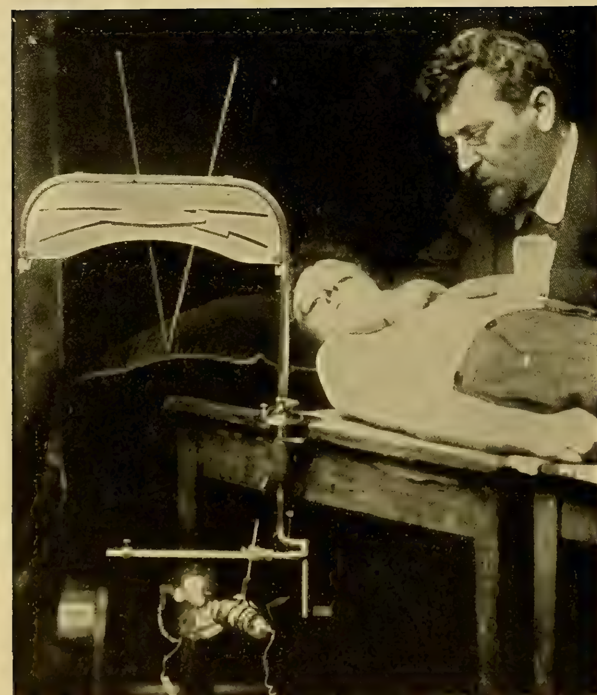


PLATE 81.—Remy Localizer. Fourth step. Now mark the two points on the skin touched by the tips of the rods. Swing the frame aside out of the way as shown in this plate. When the rods are free from the patient note the distance of the points below the frame. Then push down the rods till the points meet, and note the exact distance this is below the last position. The first measurement is the surface of the body and the last measurement is the depth of the bullet below the surface of the body in the direction shown by the two rods. The mechanical accuracy of the method is complete. During the operation the frame can be swung again into place as often as needed to verify the direction and approach to the object sought.

necessarily be found on the prolongation of one of the lines traced on it. Each of the tubes will give us a different shadow corresponding to a different line; thus, two different X-rays will exist, which we can represent in the form of rods prolonging the lines, and so know the point of intersection required—that is to say, the seat of the foreign body.

" *The seat of any foreign body visible by means of the X-rays will be shown to us when in this plane. If the foreign body is not in the vertical plane on which the direction of the X-rays is known to us, we must bring it into it, either by altering the position of the patient or that of the plane.*

" *Practical Application.*—A frame, with two opposite bars, one of which supports the two Crookes tubes, and the other a small tablet, represents the working plane of which we have just spoken.

" A system of sights allows the foci of the tubes to be always placed at the same points. On the tablet opposite, the direction of the X-rays proceeding from these foci is, with the help of the following device, represented by two steel rods:

" Two grooves describing arcs have been scooped in it, the respective centres of which correspond to the foci of the Crookes tubes. In these grooves run rings bearing rods, the imaginary prolongation of which will intersect the foci of the tubes at whatever point of the tablet they may stop.

" The frame which represents the plane must be of a considerable size—at least thirty inches wide—so that a man's body can be introduced into it.

" *Mounting of the Apparatus.*—The vertical part consists of a hollow rod, entering smoothly into a holder, and able to move freely in it. It can rise, descend, and turn. A ring placed above the holder limits the vertical movement, but allows a rotatory movement. A sort of arm which prolongs the ring indicates on a sliding rule the changes of position, and allows them to be marked.

" The holder is fixed on the edge of a table. The lower horizontal part is fixed by means of a tenon on the hollow rod. It carries the clamps which hold the Crookes tubes, two stops, and a sight. The upper horizontal part or tablet is fixed to the hollow rod by an intermediate portion, the bottom of which fits into the vertical rod, and the top holds the tablet. On the latter are the rings and the slide working in the grooves. The rings serve as sights.

" The apparatus will be ready for use when the Crookes tube has its focus at the point marked by the sights. To accomplish this, first bring round the anode so that its edge is on the line of the sight of the inferior piece; then draw out the rod from the tablet, and look through the holes of the rings it has just left. When the focus of the anode is in their axis fix the stop against which the clamps rest.

" Adjust the second focus in the same manner. A single Crookes tube can suffice for the two foci by sliding it along the lower rod. The screen is hooked on under the tablet.

"You have now only to fix the holder on to the edge of the table where the wounded person is laid.

"This table must have a top of thin material so that the X-rays may pass without any diminution of their intensity.

"*Instruction for Using the Apparatus.*—Let us suppose we have a patient with a projectile in the chest. He is on the wooden table. Place the thorax between the tube and the screen. Put the screen as near as possible. (See Plate No. 78.)

"Sight a tube; the shadow of the foreign body will be projected somewhere on the screen; move the tablet round so that the shadow may lie in its plane. Take hold of the rod which represents the X-rays proceeding from the tube in activity; bring its point to the centre of the shadow thrown on the screen (Fig. 78). A second shadow is next obtained with the same tube placed at the second focus. Bring the second rod into contact with it (Fig. 79). Mark on the skin exactly the plane on which you are. That done, take away the screen. By lowering the two rods their points will arrive at the skin of the subject (Fig. 80). If we now pierced the tissues we should reach the projectile, but we must first ascertain its depth. To do this two ways are open to us:

"1. Without moving the apparatus take a sheet of paper folded in two; place it against the two rods, taking care that it touches the skin at the place where it is folded. With a pencil draw two lines on the paper using the rods as a ruler; this done unfold the paper and prolong the lines which stop at the fold. You may see immediately the point of intersection of the lines: the projectile is at this point.

"2. By removing the apparatus away from the body with a rotatory movement on its lateral axis we can slip down the rods till the points meet (Fig. 81). Then fix on each rod a small indicator at the level of the rings. Then bring back the apparatus into its original position, and again apply the points of the rods on the skin. You will see how much the indicators have gone up. This equals the depth of the bullet.

"*The ideal we aim at is to be able to extract the projectile on the table, and with the apparatus which has already served to determine its position.* This being determined, we clear the field of operation. Then, if necessary, by a simple movement, we can again bring the apparatus into place and its guiding needles will direct us in the depth of our incisions, provided we have marked the plane of the foreign body. This can be done with mathematical precision. A horizontal stop placed on the holder of the apparatus allows us to ascertain exactly the angle of rotation, and consequently to bring back the frame to its first position. Once, twice, or ten times, we can begin again without ever making a mistake.

"*Objections and Questions.*—1. An objection has been made to me as to the necessity of having a dark-room in order to use the apparatus with the open screen. Reply.—A simple black veil, covering the screen and the head of the operator, has enabled me to localize foreign bodies in full daylight.

"2. The rapidity of the operation by which the position of the projectile is determined is such that I proposed to profit by the period of muscular resolution induced by anæsthetics to perform it and then operate immediately. A surgeon objected that the anæsthetic immobility would not be sufficient—that the efforts to vomit and other causes might produce movements. Some means of holding the patient would be necessary, he said. To this I reply that good anæsthetics have often given me a duration of muscular resolution, not only sufficient for the localizing, but for the extraction of the projectile; besides, means of securing immobility, either by plaster or otherwise, are not wanting.

"3. One difficulty in the application of the apparatus presents itself: it may happen that in the course of an operation the surgeon may be prevented from following the path of the X-rays. For instance, suppose that on the line of penetration he meets with the eye-ball or any other organ which it is important to preserve. He must abandon the straight line and take an indirect one. In such a case, we propose the use of the following method: The foreign body is to be found, as we know, at the point of intersection of two materialized X-rays. Suppose that one of our rods is of a flexible metal; it could then be bent from the groove to the point without ceasing to touch the point of intersection. This curved line will continue to serve as a guide to the operator. A series of articulated rods would answer the same purpose; the last would have a groove, and, according to circumstances, could be fixed either on the materialized X-ray or on the metallic tablet.

"*Radiography.*—When we have had recourse to radiography, we have been obliged to render the apparatus immobile in order that the first shadow projected might be clear, and to take care to move nothing so that the second shadow might be in the plane of the first.

"The plane passing through the two foci, the foreign body, and its projected shadows, is therefore, in this case, a fixed plane. As it does not necessarily pass by the focus of the tablet this latter must be displaced and brought into the plane to allow the localizing to be effected. We can be sure that if the tablet turn round the arc of the two foci producing the X-rays, it will not fail to pass into the above-mentioned plane. To this end we have constructed a separate connecting-piece on which the tablet fixed to a slide can slide and describe the necessary movement.

"*Mounting.*—The intermediate piece of the screen apparatus is removed. The connecting-piece is placed in the hollow vertical rod and fixed perpendicularly to the lower branch. The photographic frame is attached to it.

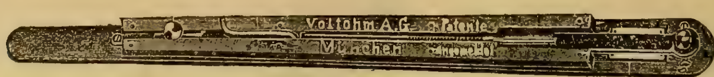
"On the connecting-piece is a slide to receive the tablet, which is exactly at the same distance and in the same position as for fluoroscope. The visual line passing by the rings which serve as sights corresponds to the centre of the anode. In practice one may successively use both processes by changing the intermediary piece without having to regulate the position of the tube.

"*Manner of Using the Instrument.*—It will vary with the parts of the trunk or head under observation, and depends on whether they are thick or not. For the trunk fix the vice on the edge of the table at the right place, already determined by a previous radiograph. Fix the rod which bears the foci by tightening a screw of the vice. Fasten the photographic frame to the curved piece. Draw out the first photographic plate. Develop it. Replace the first plate in the frame. A marking index allows you to replace it exactly as for the first exposure. Slide the tablet along the curved piece so that the rod representing the X-rays touches the first shadow. Do the same for the second proof with the second focus, and then finish as in the use of the screen.

"For radiography of the head the direction of the apparatus must be changed in order that the X-rays may meet the skull on its lateral face. To accomplish it, the vice is unscrewed, the rod laid on the table, and the connecting-piece which surmounts it fixed on this table by means of two screws. The rod into which slide the tubes, the frame, and the tablet becomes vertical. The head is placed as near as possible to the frame; it is raised a little above the level of the table by a block, and held by a band of aluminium. This band, transparent for the X-rays, serves at the same time to insure immobility and to give marks for the operation. If the needle which has served to determine the seat of the projectile cannot serve as a guide, fix on to the aluminium band another metallic rod, either jointed or flexible, as we have already indicated in the directions for radioscopy.

"*Duration of the Experiments.*—The duration of time required for radioscopic localization is *two minutes.* The duration of the radiographic process varies from nineteen to thirty minutes. We have succeeded in shortening it by taking two radiographs on the same plate, but cannot always rely on a good result from this double exposure. The apparatus can be sterilized."

The Punktograph.—A German device for localizing foreign bodies with the fluoroscope is called the Punktograph. The instrument consists of a brass ring mounted on an ebonite handle, with a dermal pencil, also mounted to the base, so that when released from a check-



THE PUNKTOGRAPH.

spring, it will protrude through the centre of the brass ring and mark the skin against which the ring is pressed. Two of the instruments are required for a cross-section localization. Either an assistant or a stationary fluoroscope will be required so as to leave both hands of the operator free. Assuming that a bullet is buried in the forearm it is engaged so that when the rings of the two Punktographs on opposite sides of the part are in line with the axis of the tube, the bullet will fall in the same line. The pencils are then released and dots marked on the skin. A similar observation is repeated through an opposite cross-section, and the bullet will be at the intersection of lines drawn through each.

The principle is the same as all methods of multiple observation, whether with the radiograph or with the fluoroscope. It will be noted that if the two rings are of the same size, the one nearest the tube will be larger than the one near the fluoroscope, and some care will be required to obtain a fairly approximate localization by this method. See also the ring-markers in the set of balls, points, rods, and rings supplied as accessories to the author's One-Minute Localizer.

Shenton's Method.—The following method of localizing is described by Shenton.

"For such cases as needles, or bullets in the hand, arm, or leg—that is, in parts easily manipulated—no special apparatus is required and no photographic process involved. Proceed as follows: Hold the part—for example, a hand containing a needle—before the fluorescent screen. Start with the screen and the anode in the tube as nearly parallel as possible. When needle and bones are distinctly seen sway the screen and hand from side to side and note the change in relation of bones and needles. It is evident that the image of whichever is farthest from you and from the surface of the screen will move the faster. If the needle moves across the bones its position is deeper than the bone; if bones move across needle the latter's position must be between the surface of the screen and the bone.

"Should the needle appear to remain stationary, place a pointer against this image on the screen and ascertain whether it moved a little or not at all. Verify these results by reversing the hand and repeating the manœuvres. A little practice enables one to give as near an estimate of the needle's real depth as any surgeon could require, and such suggestions as 'just beneath the skin of the palm,' 'midway between bones and skin,' 'lower end between bones,' 'upper end one-eighth of an inch between the skin of the back of the hand,' are in my experience sufficient for any operator. I doubt if a calculation in millimetres would be of more use. The body is an awkward thing to apply the millimetres scale to, and a little pressure on the skin, or a little swelling beneath it, will overthrow such minute calculations.

"The needle's depth being ascertained, it only remains to find its position in the horizontal planes, a task which presents few difficulties. When found this position should be marked on the skin. The advantages of this method are its rapidity of performance, the process taking but a few seconds, and the economy of material, both photographic and electrical.

"For localization in other parts of the body, and for photographically recording results, I have constructed an instrument which in principle is the same as the method just described, save that the tube is swayed while the part viewed is held in position by bands and tension springs. The tube is moved by the observer from his side of the screen, the distance it travels being regulated by sliding stops. A fine vertical wire is stretched in the centre of, and in contact with, the screen. The image of the foreign body is made to correspond with this line when the tube is in the mid position. Upon moving the tube from the extreme right to the extreme left, the image of the foreign body on the screen is seen to pass from left to right. Its relative rate of travelling compared with the same portion of bone is noted as before.

"For accurate measurement the true position assumed by the foreign body is marked by pencil on a celluloid film in contact with the screen. This measurement being secured, the distance the tube travels and the distance from the wire and the mid-point of the line adjoining the two extreme positions of the tube must be ascertained. A simple rule-of-three sum will now give the distance of the object sought from the screen."

The reader who has now carefully perused this chapter will have acquired instruction in every principle involved in the exact localization of any foreign body by the aid of the X-rays. Technics can be multiplied, but the basic principles are few. Gradually what seemed at first to be a most complex and vague process has been shown to be a mere mechanical detail that any one can work out. What early writers directed us to do with pencil and computations later ingenuity offers us means to ascertain without "formula" and without complicated apparatus. Some of the methods here described are very simple and practical, though they take up much space in the description, but it is always easier to demonstrate technique than to write it out.

An Emergency Case.—But stepping aside from the consideration of exact methods with a full equipment at hand let us take an emergency case and see what can be improvised to locate a bullet before a primary operation. Suppose a man is shot point-blank in the abdomen and must be treated where few surgical and no X-ray facilities are at command. An operation is decided on. The wound will be opened, cleaned, and sutured. The bullet is "probably" lodged in the muscles of the back, where it may become encysted and do no harm, but it is desirable to know where it is and ascertain its relations to the operation. Granted that there is no X-ray apparatus at the bedside, there are several in the city, and a truck can move one as fast as a horse can draw a cart. While preparing the patient, telephone one that can be moved most quickly, and in fifteen minutes or a half hour it can be at the operating-table.

But none of the surgeons have any localizing instruments and do not know how to use any. They have not studied localizing technics. They are in haste to get at the wound and care little for the bullet. Nevertheless, it will delay only a moment to find it, and then during the operation it can be taken out. Let the surgeon go ahead with his preparations. Let the anæsthetizer begin. Tell an assistant to connect up a tube. As soon as the muscles relax run the tube over the abdomen five inches from the skin and light it up. Let an assistant drop under the table with the fluoroscope and find the shadow of the bullet, which is undoubtedly near the back. When found have another nurse move the tube so that it is vertical over the bullet, being directed to the proper position by the watcher with the fluoroscope under the table. Then let the nurse lay on the abdomen a pair of artery forceps and move them till the fluoroscope shows that the bullet-shadow is rimmed by one of the handles. Then have the nurse slip any long metal instrument with a small tip under the back and shift it till the fluoroscope finds the tip in the same line as the shadow of the bullet. The job is nearly done now. It has taken only while the surgeon is washing his hands, and has delayed nothing. Let the assistant at the fluoroscope still, for a second more, sight the line of the shadows as above. Let the nurse shift the tube a foot or so horizontally. How much has the shadow of the bullet left the line of the front and back markers? If very little, the bullet is very near the back. If very much, it is nearer the front wall than was supposed. The watcher with the fluoroscope can judge the approximate depth by the comparative amount of movement out of the line. Then all is ready. Remove the tube; note that the bullet is in the line between the front and back markers at an estimated depth from the back; let a nurse register the location; and proceed with the surgical treatment of the case. As sterilized instruments were used the operating field has not been interfered with, and the time required has been part of the general preparations. The absence of complete apparatus has not presented an insurmountable obstacle to localization. Having found the site of the bullet the question of its removal can be discussed in the light of exact knowledge instead of ignorance.

In these directions it has been assumed that an operation was planned. The records of war (and some of them are stated in our chapter on X-rays in military surgery) do not greatly encourage such operative interference. The sad result of but a few months ago is eloquent with lessons to optimistic surgery which has boasted its science above medicine. We simply point out that if an operation is impending the bullet can be found by the above impromptu technic, and if no interference is designed the same technic can at a convenient time be used minus the anæsthesia to locate the bullet without harm or disturbance to the patient, simply for the satisfaction of knowing where it is.

An X-ray examination is not a desperate resort *in extremis* as many of the public judged it to be from the Buffalo bulletins. At this late day we see in sorrowful retrospect that the question of immediate localization was of the utmost insignificance. But friends of surgery will regret that the X-ray question was not handled with candor to the public and with the decision of competent X-ray knowledge. So far as we have conversed with lay (and the same is true of medical) remarkers on the keenly disappointing case two impressions made their way into the general mind: (1) that an X-ray examination would have been so severe a shock or *ordeal* that the President could not have endured it; (2) that the bullet was not located because none of the surgeons in the case knew how to do it, and an outside expert was refused from over-confidence or prejudice or to avoid an exposure of said ignorance. The author, however, has no personal comment or criticism to make on these wide-spread impressions. He does not know the true facts. Nor does the official medical report of the case made public on October 19, 1901, appear to throw additional light on the subject. The vital surgical question on September 6th was one of non-interference and not of X-rays *per se*, and this being so it would have been well to have adopted a different attitude toward the great popular anxiety as to an X-ray diagnosis; an anxiety fostered by repeated *surgical* statements that "the X-rays would have saved Garfield." After the probe has been used it is too late to employ conservatism. X-rays then are like locking the stable door after the horse has been stolen.

Without in any respect implying that human skill could have changed the event in the stunning tragedy that closed our President's career, yet, if mistake occurred, close study of the lesson is the best way to profit by it. For this reason only we suggest that every surgeon who may be suddenly confronted with the need of caution in a fierce trial of judgment should read this verbatim extract from the Report of the Medical Department of the United States Army in the war with Spain.

"*When the probe, or one of its substitutes, is used one of the*

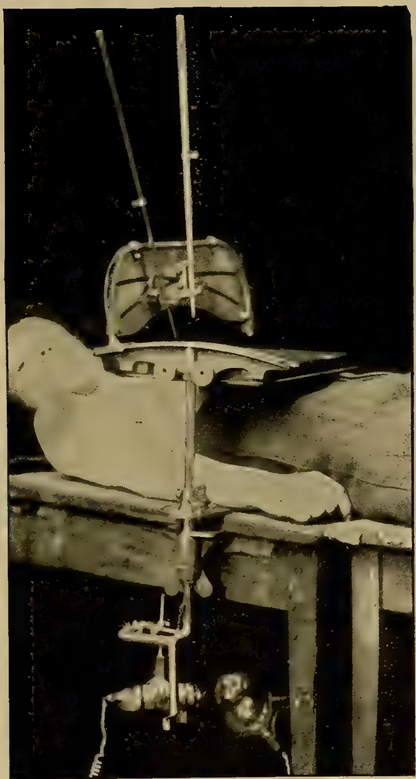


PLATE 82.—Remy Localizer. In this plate is shown a modification of the device and its position for trunk and extremities.

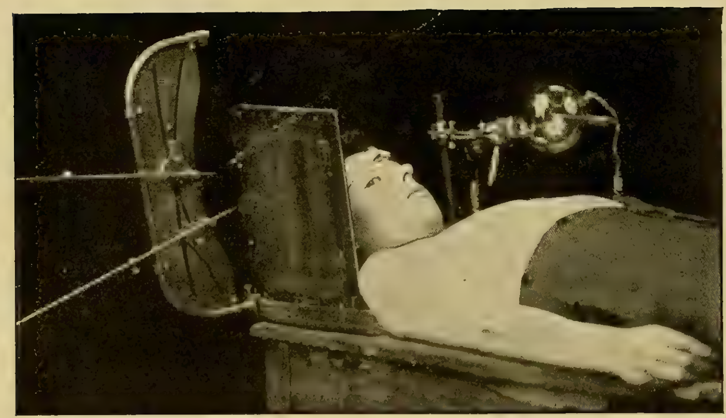


PLATE 83.—Remy Localizer. This plate illustrates another adaptation of the device and shows its position for the head. The study of these plates and description in the text will do much to make clear the identity and essential simplicity of all systems of localization. But two things are required: First, the vertical axis of the rays; second, the depth below the surface at which two converging axes in the vertical plane intersect. The foreign body is right there. The plates illustrating this Localizer are used by permission of Messrs. Rebman, Ltd., of London, and are from the Archives of the Roentgen Ray.

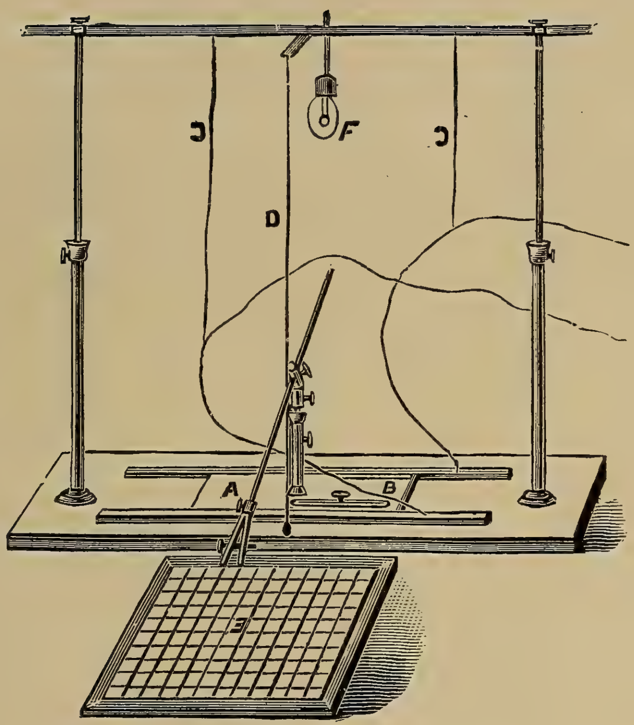


PLATE 84.—The Combined X-Ray Tube Holder, Localizer, and Stereoscopic Picture Producer, designed by Dr. Hall Edwards, is one of the most convenient tube holders, and is capable of holding the tube and conductors from the coil over any portion of the body on a bed or couch. In addition, by a few simple movements and a simple calculation, the position, distance from the surface, the size of a foreign body, can be ascertained. With it is also sent out a special plate holder, which enables the operator to produce stereoscopic pictures with ease and accuracy. This Localizer is both convenient and simple.

tenets of modern military surgery (non-interference) cannot be followed, and septic infection is made possible or probable. With the Roentgen-ray at hand the surgeon can locate a lodged missile at any time when necessity demands, and its track can be safely *left undisturbed.*

"The unreliability of the probe for locating lodged missiles is well known. With the probe it is possible to follow only a small minority of bullet tracks. The contractility of the tissues may interpose obstacles to its passage and a change of position on the part of the patient may cause such a shifting of muscular and fascial structure as to completely obstruct or alter the path made by the projectile. In fact a great majority of cases where the bullet has been located by X-rays show clearly how impossible it would have been to determine the position by means of the probe.

"But *not only is the probe unreliable, but it is a source of danger even when used with all possible aseptic and antiseptic precautions.* The experiments of LaGarde, Delorme, Habart, and Faulhaber have shown that in practically all bullet wounds some foreign matter and bacteria are carried into the wound. The number of bacteria so carried in *are not usually sufficient to produce surgical infection and subsequent inflammation and suppuration, provided the wounds are protected from further infection and are left undisturbed.*

"For undoubtedly *the factor of non-interference with the wound is of great importance.* No sooner is a traumatism inflicted than natural processes are brought into action for protection and repair. There is a local increase in vascular activity, serum is poured out, leucocytes accumulate, and the defensive factors of phagocytosis and serum bactericidal action are brought into play. That these factors may have best opportunity for action, rest and non-disturbance of the tissue are necessary.

"*Mechanical disturbance of the tissues by probe, by the finger, or by instruments will produce fresh traumatisms and cause disturbance of the defensive action going on, and these traumatisms and disturbances (however slight) will favor growth of the bacteria and add to the defensive labor required of the tissues. So that even aseptic or antiseptic operative or explorative interference may throw the scale on the side of the invading bacteria and lead to troublesome or disastrous consequences.*

"For these reasons, and in consideration of the unreliability and danger of searching for a bullet through a wound, it may be stated that such search is contraindicated except in cases where the immediate danger from the presence of the bullet is greater than the possible consequences which may arise from interference."

In the official report by the chief operator in the President's case we read: "*By the passing of a probe* it was found that the bullet had entered the abdomen."

It is useless to cite the description of the laparotomy and entire operation, which we assume to have been performed with skill, but among the editorials of the medical press on the result one states:

"*The immediate or ultimate shock succeeding* (*operation*) *is invariably very great. There is no case of recovery yet recorded after laparotomy for gunshot wound of the stomach in one over fifty years old.*"

On October 26th, the Philadelphia Medical Journal editorially remarked:

"We have pointed out from the first in these columns that the President suffered from the effect of shock—*shock caused not only by the assault, but especially by the operation.* This was inevitable. The patient went on the operating-table with a pulse of eighty-four and left it with a pulse of 124. His pulse never really rallied after the operation; it never regained anything like a satisfactory tone."

From this we may turn to the constant advice of leading military surgeons for the past two or more years and study as to what might have been the result of occlusive dressings and no surgical traumatism or shock. But here, in the fact of the shock and the pulse, we have a direct and plain indication of the powerful action of the galvanic current on the spinal centres and the heart. That this prince of remedies for shock was not brought to the President in his great need must always grieve the profession. Its physiological action has been so widely known since the classical researches of Du Bois Raymond and others that every standard text-book on materia-medica and therapeutics teaches, as do standard works on Physiology, the "nerve and muscle effects" of anelectrotonus and katalectrotonus. It is without doubt the most powerful remedy against shock. Over and over again in our own clinical experience it has quickly rallied patients from profound shock, from apparently imminent heart failure, from grave nervous depressions, collapse, etc. Think of how simple a remedy it is. Study its swift action in a crisis. Read and test how it energizes and refreshes fatigued muscle-fibres and pours new strength into exhausted nerve-centres and then ponder on a patient left without its aid. That we may all profit by these studies of this phase of the case is the earnest wish of the author.

This sad and important case has a deep interest from several standpoints, and in no spirit of controversy, but with the desire simply to place the vital surgical question before us for wise and conservative study we make the above citations. The reasons given to the public for not locating the bullet at first with the X-rays could hardly have held at the autopsy at which "the search for the bullet exceeded the time allowed and was discontinued at the request of those in charge of the body." Still, it was not found. A glance with the fluoroscope would at least have given its approximate situation. See war records on localization of bullets by X-rays.

CHAPTER XXV

MEDICO-LEGAL RADIOGRAPHY

Useful Precautions. Liability of the Examiner. Verdict against Defective Technique. A Prosecution and a Precedent. Post-Mortem X-Ray Penetration.

The physician or surgeon without experience in law, or special knowledge of the laws of evidence, and who is called for the first time to make a radiograph for testimony in a lawsuit, must begin at the very beginning to create evidence that will possess medico-legal value. It will be impossible to set forth in this place the attitude that any particular judge may maintain, nor need the already extensive list of precedents be cited. A picture may be rejected for various reasons not connected with the medical aspect of the case, but to be admitted as competent evidence the surgeon should be prepared to show proof of *every step in the making of the picture which connects it with the case.*

By marks of identification and by a witness be able to show that the glass plate which is to be exhibited in Court was the one placed under the patient for the actual making of the radiograph. Make a written note of every detail of the technique with which the exposure was made. After the exposure every move of the plate should be connected by proof. If not developed by the surgeon care must be taken to prove its delivery to the photographer, and the photographer must guard against weakening the evidence. It may have to be proved that the plate was not *changed* or *altered* in any way, and it must come into Court with absolute proof that it is the correct and identical picture made by said surgeon of said patient at the time and place and under the exact conditions described. As a picture might be substituted, or might have been taken before or after the time at issue, the chain of primary evidence by which the surgeon proves his making of the picture and its unaltered presentation to the Court may be of very great importance.

At the time of making the picture a full fluoroscopic examination should be made and details of the findings recorded, together with the technic of the methods employed. As it may be open to question what efficiency was possessed by the apparatus which took the picture and also what precautions were taken to insure *an accurate showing in the picture* of the condition which is at issue in the case (as, a fracture), it is important to protect these matters with proof.

The author's Register of X-Ray Penetration will prove the intensity of action during the exposure; testimony that the plate and tube were centred by the author's Position-Finder will certify to the elimination of distortion; on the plate itself the shadows of the author's Distortion Landmark will furnish unimpeachable evidence as to the degree of deviation of the axis of the rays from an exact perpendicular. The author's Divergence Chart,* which is a standard representation of the path of X-rays, will be useful in such explanations as may be called forth by counsel.

The interpretation of the testimony in the picture itself will have no value in Court unless the chain of evidence *connecting the picture with the case* is complete, and the final interpretation follows the law governing other expert evidence. As a personal precaution in the remote liability of a suit *against the surgeon for alleged damages to the patient on account of the X-ray examination* it may be a wise routine to secure a legally executed release from all responsibility, signed by the patient and duly witnessed, in advance of making the radiograph. There may be no danger or actual injury in 1,000 or 10,000 exposures, but self-protection is better than the annoyance of litigation.

A study of the following remarks by an attorney on the subject of the X-ray in law will be instructive:

"The question which propounds itself first is whether an X-ray picture may be introduced in evidence on the trial of a case as proof of the existence of the condition by it shown. Thus in an action for personal injuries may the X-ray picture of a fractured limb be put in evidence to show the existence, the nature and extent of the fracture. It is now the best opinion that *it may be so introduced* and that the jury may be permitted to inspect, provided always that the condition to be shown by the photograph is in issue or relative to the issue at bar. Furthermore, a photograph being from its nature secondary evidence merely as contra-distinguished from the best evidence, the proper foundation for its reception as evidence must be first laid by the party introducing it.

"Thus the expert must first testify to the reliability of the machine, its nature and process, the degree of exactness, etc. The reason that it is of any legal value at all in the trial of a case is the fact

* Along with this chapter should be read the sections relating to the above-mentioned special aids to accurate X-ray work.

that science and human experience have proven that the X-ray machine is capable of giving an exact reproduction if properly and scientifically used. Hence the necessity of first showing, and this carefully, that the machine and the working of it in the particular case at bar were all that was necessary for a complete effectiveness. The sufficiency of the proof first required to verify the picture is a preliminary question of fact for the judge presiding at the trial and is not open to exception. The statutes of New York State provide that in an action for personal injury, the Court, on the defendant showing certain facts by affidavit and applying therefor, may direct the plaintiff to submit to a physical examination by one or more physicians or surgeons to be designated by the Court; and such examination shall be had and made under such restrictions and directions as the Court shall deem proper. Now, then:

" *Question.*—Granted the fact that the X-ray machine has certain remotely dangerous qualities inherent in its workings, may the Court, nevertheless, order the plaintiff to subject himself to its dangers?

" *Answer.*—It will be noted that the statute referred to gives the Court power to make such restrictions and directions as it may deem proper. It will be seen, therefore, that whether or not a plaintiff must submit himself to X-ray examination, is discretionary with the Court. It could not well be argued that the plaintiff could object to the use of a thermometer, for instance, or a stethoscope in the hands of the examining physician. Why then to the use of any other instrument recognized by the medical and scientific world and necessary to the examiner in acquiring the information sought?

" No case touching the subject has yet been brought before the Courts for adjudication. It has, however, been decided that the section, so far as ordering a physical examination is concerned, does not violate any constitutional inhibition.

" *Question.*—Suppose that upon subjecting himself to the machine, if so desired by the Court, he were injured thereby; *has he redress* for his injuries, and *to whom could he look* for such redress?

" *Answer.*—In case of injury to plaintiff by use of the X-ray machine *he would have redress.* The judge ordering the examination would incur no liability. He acts merely in a judicial capacity, in which he is called upon to exercise his discretion; and he is not liable for error of judgment even though it be alleged that he acts without due care and prudence.

" The injured plaintiff's remedy must be sought *against the physician, under whose charge the instrument was at the time of the accident.* Hence, if it be charged and proved that the physician in charge of the machine did not use proper care and prudence in handling it, he must respond in damages to the one injured through such negligence."

There is an old saying that a word to the wise is sufficient, and, in view of the uncertainty of courts and juries and the fact that the examining surgeon seems to be the probable legatee of all trouble arising from mischance with the X-ray apparatus we again suggest the precautions: get a release in advance and be sure to use "approved technics," and be able to prove that such alone were used. To these precautions add a third one. *Fully advise the patient* that certain ill-effects have been known to occur from prolonged use of the X-rays, explain the nature of them, the chances of their occurrence, and see to it that in consenting to the X-ray examination he understands clearly just what he is doing. He cannot then charge that he was not informed of any liability.

In general, in regard to suits against surgeons for damages in cases of alleged X-ray injury, it would appear that ample protection may be found in following approved rules of technique, and that liability will probably result from ignoring them. *The rules of reasonably safe procedure are so absolutely simple* that no person can excuse himself for not adopting them, and proof that all due care had been exercised in this respect would probably give the surgeon the verdict. In the notable case in Paris, March, 1901, the verdict went to the plaintiff because the Court found that the radiographer had acted more like a *workman* than a medical man. The facts are thus taken briefly from the London *Lancet:*

"The Paris correspondent reports the case of a lady who prosecuted a medical radiographer for having, as she alleged, injured her by burns produced by the X-rays. She was suffering from sciatica. The leg was exposed on three occasions for forty, forty-five, and seventy-five minutes respectively. After the first two exposures, the skin became red and inflamed, yet the treatment was continued. The result was an extensive burn of the third degree. Physicians who were appointed as expert witnesses testified that the radiographer was not responsible, but they regretted, however, that no attention was paid to the signs of inflammation present at the end of the second sitting. The Court gave the full amount of damages asked for (5,000f.), finding that the radiographer had acted imprudently, *more like a workman than a medical man, and that his apparatus was defective.*"

There is a wealth of suggestion in this finding of the French Court.

In the case of Burns *vs.* Brooklyn Heights Railroad Company, November 26, 1901, a surgeon attempted to explain to the jury the alleged injury to plaintiff's right shoulder by the aid of the X-rays. Counsel for the defence objected to the X-ray pictures "on the ground that they were *shadow* pictures and incompetent and improper evidence for that reason." A long discussion as to the definition of shadows between surgeon and counsel *was followed by the admission of the evidence* and testimony was continued.

This will be a common contention of opposing counsel till the error of regarding radiographs as mere "shadowgraphs" is established among the ignorant and the laity. That the contention is unfounded will appear on *inspection* of the given picture. It is not a question of opinion but of a fact visible to the ordinary eye. Any picture of a "shadow" will exhibit its true character on sight; or, at least, will not appear to be any other kind of a picture. The image of a *shadow* may be produced on a sensitized plate in one of two ways: an object may be exposed so that light acts on the emulsion only around the outlines of the object and thus leaves an opaque shadow on the developed plate, or a camera can photograph the shadow of any object. Every one has seen such shadow-pictures, and they show for just what they are.

The common photograph—of portraits, animals, buildings, scenery, etc.—is the reduced image of the surface-appearance of the object, reflected into the camera.

The standard radiograph is the life-size image of the object made by direct transmitted light which passes through the object exposed and prints on the emulsion not only the outline, but the detail and plan of all varying densities in the structures within the surfaces of the object. It is a high-class photograph by transmitted light, comparable in qualities of true imagery with the best photography by reflected light.

Now, it is possible to so expose an object to X-rays that the feebleness of action on the emulsion will image no more than the mere outline or opaque shadow on the plate, but, if penetration and definition are attained in a true radiograph, the facts show in the picture and cannot be argued away. Therefore the decision that a given radiograph is a "mere shadow-picture" must rest on its character as such in *fact*, and the question of fact must be decided on the evident appearance of the picture submitted.

Upon the ground that skiagraphs were destined to figure largely in suits for damages after accidents and in cases of malpractice, a committee was appointed by the American Surgical Association to inquire into, and report on, *the medico-legal relations of the X-ray*. A circular letter was sent by the chairman to every member of the Association, and from the replies received conclusions were drawn which were published in eight sections in July, 1900. Many medical journals spread these conclusions far and wide, and, probably, thousands of physicians and surgeons who never did any X-ray work themselves will base their opinions upon this public report. It was an unfortunate and premature document. Experts are raising the standard of the best radiography in a really remarkable manner as compared with average mediocre work which keeps in unprogressive channels, and doubtless the next five years will see many of the opinions of to-day as much changed as mechanical devices will change and improve. When X-rays are twenty years old instead of five the quality of "average" work may equal the best of the present time.

A Prosecution and a Precedent.—When the unexpected happens and the unpleasant surprise of litigation ensues we may be sustained by a precedent which it is a pleasure to here present in brief for the gratification of all. Dr. L. A. Perce, of California, was the victim of the prosecution and historian of the event, which we shall let him relate in his own words:

"The great interest to me of this, my first experience in injuries of X-ray, prompts me to give the full history of this case. I had been using the apparatus almost continuously for eight months before this so-called burn occurred, without the least sign of skin irritation, as well as since the injury, with still no further influence. I use a Ruhmkorff coil, capable of an eleven-inch spark. I operate it by the 110 V. current from street circuit. I control my voltage by the use of ten thirty-two candle-power incandescent lamps, placed in series, reinforced by a sliding Rheostat. This gives me ample power, and permits of a wide variation, as I may see fit to cut out or in any number of lamps.

"On January 20, 1900, one A. L. Bancroft came to me with a history of injured right shoulder of eighteen months' standing, and wanted a radiograph of the same, stating several physicians said his shoulder was dislocated, and others said it was not; he stating that when doctors disagreed, who could settle the point except the X-ray. I placed him upon the operating table, with coat, vest, and suspenders removed, with a plate under right shoulder, a good tube ten inches from his shoulder, in a five minutes exposure. When the plate was developed, I found it badly fogged. On January 24th he returned; an exposure of ten minutes given at fourteen inches distance, and no picture obtained. On January 27th he again returned and I made two exposures, at sixteen inches; one of fifteen minutes and one of twenty-three. This time a fair picture was the result, showing the true condition of shoulder-joint.

"My subject was a very large, thick chested man, weighing 220 pounds. He stated that in about two weeks a bright red spot, some three or four inches in diameter, appeared upon his right breast, above and to the right of the nipple, which later produced a sore and was hard to heal. He, also, claimed sharp pains ran down his right leg to knee; then below this point to heel, and finally to bottom of foot.

Also, his beard on the right side of his face fell out, but finally returned.

" Soon after this, he wrote me, charging me with responsibility in the matter sufficient to warrant him in demanding of me compensation to the amount of $300. This I at once refused, as I felt in no wise to blame, and not wishing to stultify myself and establish a procedure in such a case, refused to comply with his request for any remuneration whatever. Consequently, his attorney, in July, 1900, began suit against me in the Superior Court of Los Angeles County, for damages to the amount of $5,000. The case came to trial upon January 14 and 15, 1901, and after less than ten minutes deliberation by the jury, they found a verdict in my favor. Many interesting points were presented during the trial of the case, showing how necessary it would be that one operating with the X-ray should fully give their subjects to understand accidents had occurred from its use, and others may happen. I took the precaution to advise him that cases had been recorded where it had produced what was called a burn, but I had never seen one. This he corroborated himself upon the witness stand, and Judge Shaw *held this to be sufficient warning, even if such warning should be required.*

" The plaintiff introduced two witnesses as experts, who directly testified no blame could attach to me operating any kind of a machine for X-ray purposes when ordinary care was employed, such as even far less than I had employed in this case. While no protection such as aluminum plates or any intervening metallic substance was used I did carefully cover his face and shoulder with clean sterilized towels. Dr. Yoakum, one of their own expert witnesses, stated he had a number of times burned subjects, and some in less time, and others in greater or longer exposures. Dr. N. N. Morrison, Chief Surgeon of the Santa Fé Railroad, another of their witnesses, testified he, himself, had submitted to three exposures for diagnostic purposes of thirty minutes each upon succeeding days, and received a very severe burn of the whole abdomen and right hip; this, too, by a man in whom he had, and did still place, the utmost confidence in his skill and knowledge, and in no wise did he consider him, nor his apparatus, to blame. He further expressed himself as a firm believer in the accumulative theory of the ray as well as possibly the peculiar condition of the salts of the body in some subjects, making them partially susceptible to the chemical action or effects of the ray.

" Only one witness saw fit to do all in his power to fasten the blame upon the operator, and he knew nothing of the principle or character of the X-ray, but lays claim to being a skin specialist. His testimony was accepted by the jury as a huge joke, and he left the stand weaker than upon taking it. In my defence we saw fit to introduce only two witnesses, as our case was made clear by the testimony of those they expected to prove my negligence, carelessness, and unskillful application, with which they charged me in their complaint.

" In conclusion, permit me to say, that if I have been able, in defending myself in this unsought and uncalled for prosecution, to half establish the fact, that as medical men *we can use, and are willing to use, all modern and approved appliances for the purpose of diagnostic and therapeutic effect, among which the X-ray stands prominent, and feel some full degree of security granted and secured by law*, I shall feel no regrets from worry of mind nor financial consideration."

Post-Mortem X-Ray Penetration.—Among the various legends relating to the X-ray was one to the effect that the rays "would not penetrate a dead body." "Is it true?" was asked of an expert radiographer connected with a large medical college. It would seem needless to take such a report seriously in a book for the educated profession, but we are not sure that even this "X-ray fallacy" has not victimized its thousands, and it is not safe to pass it without a word. Said the operator referred to: "My experience disproves it. I have done a great deal of work with cadavers, and never had any difficulty in getting good radiographs. Some time ago I was asked to take a portable apparatus and go to a man and examine his heart and lungs. When I arrived the man was dead, but the relatives thought he was only in a trance and were afraid of burying him alive. I made the examination. The man was dead, but there was no difficulty in studying his heart and lungs."

In the historic year 1896, one of the leading experimenters in Boston made scores of radiographs showing detail that was surprising till it was learned that the subjects *were very still* during the exposures because they were parts of *cadavers*. The fact was not concealed, and the only reason for using cadavers was to study the fractures, dislocations, and traumatisms that were rapidly manufactured for the purpose of X-ray investigation.

In December, 1898, a very skilled demonstrator of anatomy in a medical college, who was also an expert radiographer, wrote of his attempt to radiograph blood-vessels, and in an elaborate article said:

"The accompanying illustrations (thirteen) were made on three dead bodies. The statement has been made that dead tissue is very much more impervious to the rays than living tissues. Accordingly I made the exposures longer. But in figure 3 is shown a controversion of the statement. The two hands there shown are the right hand of subject No. 1, and the corresponding hand of a living young woman who kindly placed her hand on the plate and allowed me to use it in comparison. Both hands were about the same thickness; the tube was so placed that it was in the same relation to both hands; and the exposure was three minutes. In photographic development both are exactly the same in clearness of definition, and no difference appears. This fact, however, was not ascertained till after all the other radiographs had been made, hence the far longer exposures than were necessary."

If any reader wishes to test the matter personally he need not be deterred by lack of a cadaver, but can secure joints and steaks from the nearest butcher shop which will serve as comparative substitutes.

CHAPTER XXVI

BINOCULAR RADIOGRAPHY

STEREOSCOPIC TECHNICS. THE TWO-FOCUS EXPOSURE. THE REAL X-RAY PICTURE. APPLIANCES NEEDED AND SIMPLIFIED DIRECTIONS FOR BEGINNERS. HOW TO EXAMINE BINOCULAR NEGATIVES.

Stereoscopic Radiography was first suggested in this country in March or April, 1896, and is the ideal of X-ray representation. But so slothful have American surgeons been in developing facility with the by no means difficult technic, that even in 1902 not one operator in 1,000 makes his radiographs show the part in other than a flat plane. It is difficult to explain why so superior a method should have been neglected. Perhaps because no one has led the way and employed the degree of persuasion needed to awaken the medical profession to the merits of the results.

It is certain that one view of a fine stereoscopic X-ray picture is enough to spoil the eye for the usual flat print. The view is not only a life-like relief of the part, for instance, an arm, but it is an instantaneous localizer, giving the shape, size, and position of the thing seen. The full detail of an X-ray picture cannot even be guessed at—the possibility of X-ray diagnosis cannot even be estimated—*till the stereoscope teaches it.*

One sight of the striking stereoscopic effect in contrast with a plane picture is enough to make the observer enthusiastic. Why, then, is it neglected? It supplies just what diagnosis most needs. It obviates the complaint that all the shadows of the picture are in one plane. It frustrates "distortion," for there is no "distortion" in the stereoscopic-radiograph. To say that it would clarify X-ray diagnosis a thousand per cent. would be conservative. Then why is the method not in general or even exclusive use? Why is any other method employed save that which shows what everybody wants the radiograph to show?

Is not a picture which is like looking into the part instead of at a flat and vague shadow of the part worth making? Do surgeons not want the kind of radiograph which will best and most accurately aid the diagnosis? Does no one think it worth while to even feel casual interest in the means of quadrupling the surgical value of X-rays? In theory every one yearns for new discoveries and progress: practically, one "discovery," aged now about six years, contains more potential progress in X-ray diagnosis than anything else that can be named or needed and is ignored by surgeons as if it was not going to be discovered for fifty years yet. Mention of the simple fact is instructive. Those who wish to be exceptions to the passive attitude of the majority can learn how to make stereoscopic X-ray pictures with very fair success by reading the directions in this book. A little extra trouble may be involved, but practice makes it easy and the recompense is great. The modern self-regulating tube has removed one of the former difficulties of making the two exposures alike.

Let us now see just what it is that is offered to surgical diagnosis by X-ray stereoscopy. Imagine yourself blind in one eye. You go through the world with a deficient perception of relative shapes, distances, positions, proportions, perspectives, etc., of bodies and groups of objects that you see. A radiograph taken with one focus of rays is a picture seen with one eye. It is in one flat plane without perspective and with the relative distances merged. Sense of position is feeble; form is deprived of body, and contour is only dimly suggested. A normal view with two eyes gives shape and true perspective to bodies seen. Binocular vision can estimate distances, and relative positions are correctly seen. The superiority of binocular vision over the vision of a single eye is incalculably important to the individual and a working world of one-eyed people cannot be conceived. So inferior is vision without the sense of proportion that mechanical progress would stop if the world had no inhabitants with two adjustable foci of sight.

Make an X-ray picture with two foci of sight and we at once get binocular vision effects. The one-eye, plane, proportionless, mediocre image on the film is transformed into the proportions, relations, and defined body-revealing image created by two eyes. The binocular radiograph is the stereoscopic radiograph, and, when viewed with binocular eyes in the merging mirrors, the surgeon's vision takes the place of the Crookes tubes and successfully sees in true form, proportion, and perspective the images of the internal structures. The advantage is apparent without argument. There is no real X-ray picture other than the binocular picture, just as there is no true vision with complete functions except binocular sight. One eye does not count in scientific consideration of full vision, though it is vastly better than none to the owner, and one-focus radiography has no greater claim to value in the surgical consideration of full two-focus radiography, though a plane picture is better than none at all.

The single-focus X-ray image limps toward a diagnosis like a paralytic with one leg; the binocular X-ray image stands out boldly on two feet and tells its story at a glance. The time lost in efforts to study out the diagnosis by plane pictures in many difficult cases would suffice to make binocular originals ten times over. The more decisive certainty of the diagnosis is an advantage that cannot be computed on a time basis. Let us now see just what tools and technic the binocular radiograph requires, and what demands it makes on the surgeon or his assistant.

A well-equipped X-ray laboratory or surgeon's exposing-room will not need a single extra tool. Appliances fitting the operator to do single-focus radiography will enable him to make binocular radiographs. The essentials are:

1. An ordinary exposing-table to hold the patient.

2. A tube-holder to hold the tube. A horizontal bar on which the tube-holder will move one and one-fourth inches to the right and left of the centre.

3. A plate-holder frame which will let the exposed plate drop down and be removed and a second plate inserted without disturbing the patient.

All else is the usual electrical and Crookes tube equipment without change. It is very desirable to have the two exposures equal in photo-chemical action on the films, and when operated by guess the variations of plain tubes made this uncertain. By the aid of a tube which will hold a regulation to which it is set, and by regulating its radiance to a desired light with the aid of the author's Penetration Gauge the element of uncertain equality in twin exposures gives place to mechanical measures of value.

A distinguished surgeon and member of the faculty of a renowned medical college, who states that he now makes *all* his radiographs for stereoscopic effects, has contributed a very illustrative article on Stereo-skiagraphy which ought to do much to lead readers to do the same thing. For its plain, sensible, informing, and educational example we quote it in great part here.

Technics.—"Stereoscopic vision is due to the fact that we have two eyes placed at a distance of about two and one-half inches apart, and each eye sees a different picture from the other. The brain coalesces the two pictures so that we see only one and that has the appearance of solidity. To produce this result in the radiograph is of the highest importance to the surgeon, and it is obtainable in the following manner:

"Place the tube vertically over the part with the target parallel to the horizontal centre of the plate on the exposing-table. The distance from the anode to the upper surface of the part may be twelve inches, or any preferred distance. Centre the plate with a plummet and fix the tube so that the focus is first one and one-fourth inches to the *right* of the plumb centre line. Then pose the tube so that *the axis-ray from the focus will pass through the spot where the plumb-ball centre touches the upper surface of the part.* Then make the exposure as usual. Next remove the negative and without moving the part slip a second plate in the same position and shift the tube one and one-fourth inches to the *left* of the plumb centre on the same horizontal line. Again turn the focus point of the anode so that a line from it to the plate will pass through the same spot on the upper surface of the part previously marked by the plummet. Then make the second exposure. Develop both negatives in the usual manner.

"These two pictures are now fac-similes of the pictures that would be seen by the two eyes at twelve inches distance, so far as respects relation and position of the bodies viewed. The central axes of the rays from the two tubes cross each other similarly to the visible threads of the familiar cross-thread localizer and thus produce the stereoscopic effect, giving visual localization.

"If a case requires immediate operation and the surgeon wishes to quickly see the position of the parts the negatives may at once, as soon as fixed, be placed in a frame with a ground-glass background, illuminated, and viewed in Wheatstone's reflecting stereoscope, which any one can make by obtaining a couple of squares of mirror four inches in size, fitted together at right angles. Then by putting the nose to the junction so that each eye looks equally into each mirror, and, placing the pictures at right angles to a line drawn through the centre of both mirrors and ten or twelve inches to the right and left, the image for each eye will be presented to it, and the single coalesced result will appear as a solid body, every part taking its proper place and relative distance. If it is desired to obtain a print it may be done by taking the wet negative just after fixing and washing, moistening a sheet of velox or other developing paper, applying it to the still wet negative and exposing it to the gas-light or other light and developed in the ordinary way. When fixed the prints may be laid on a piece of glass while still wet, and put into the stereoscope and viewed.

"If desired the pictures can be reduced to the size of the ordinary card-mount for viewing in the regular refracting stereoscope. In taking and in viewing these negatives and prints it is necessary to

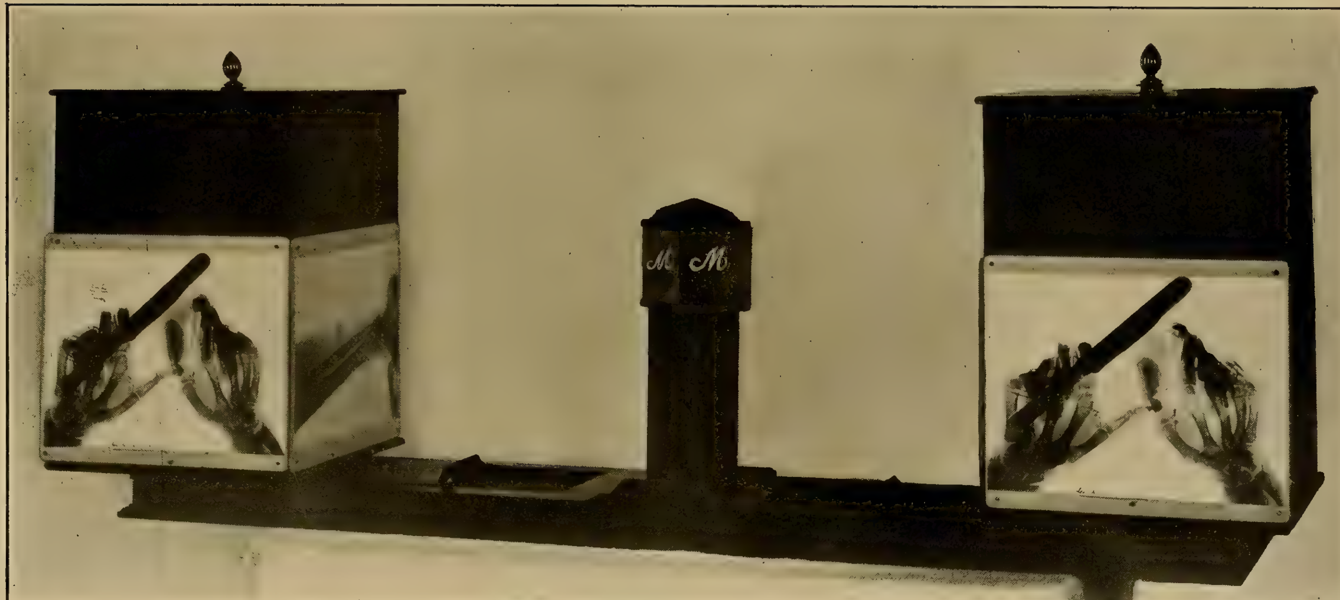


Plate 85.—Author's Stereoscope for Examining Binocular Radiographs. A set of four pairs of prints can be tacked on the square pillars and examined in succession by turning the pillars round on their pivoted base. These pillars slide on a sledge to any focal distance from the pair of small mirrors set at right-angles on the central post and marked MM. This post slides backward and forward to any focus. For inspection level the two prints with their lines running in the same directions as shown by the two knives in the plate. Then—(See next plate).

Plate 86.—Place the stereoscope so that the light will equally fall on the right and left sides of the view, sit in front of the reflecting mirrors with the bridge of the nose engaging their angle of meeting and each eye looks squarely into one mirror. Then with each hand draw up or slide back the pillars till they are equally in focus with the eyes and both pictures appear as one. Complete the exact adjustment by sliding the post with the mirrors till the landmarks of the two pictures exactly cover each other. The view is then correct. In this photograph the author is viewing the leg containing bullet on inner sides of pillars. To view the hands cutting pear the pillars must be given a quarter turn to bring them into a position facing each other and the mirrors.

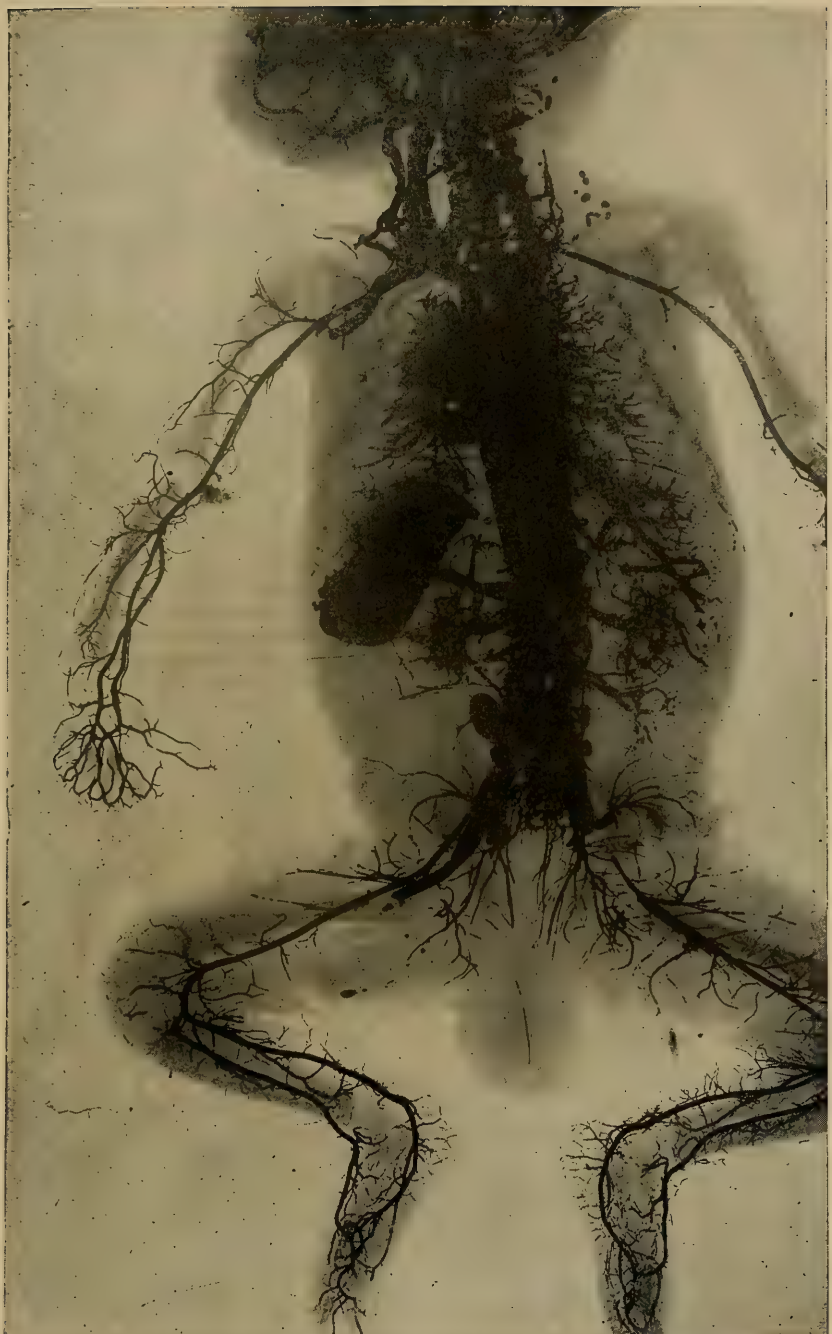


PLATE 87.—Study of the arterial system in an injected infant.

See following page for description.

STUDY OF THE ARTERIAL SYSTEM IN AN INJECTED INFANT.

This subject, a still-born infant, full term, was injected with four pounds of mercury, the needle being inserted into the external circumflex branch of the femoral artery and connected by a rubber tubing to a funnel containing the mercury, which was allowed to run in of its own weight under a pressure of a sufficient column. The injection was watched through the fluoroscope. The exposure was 20 minutes with the anode 24 inches above the centre of the plate, using a ten-inch coil. The detail preserved even in the reduced cut is well worth a great deal of careful comparison with the reader's own work if he is a beginner. It is by comparison of many radiographs that skill in interpretation can best be acquired. Negatives that look very nearly blank to the non-medical *professional* photographer accustomed to portraits and interior work will tell much more of a story to him who can read the shadows than does the microscope in many cases. A pair of stereoscopic pictures would show this detail to far better advantage. (Rebman, Ltd.)

be particular in the various processes of copying and printing to bear in mind the changes of reversal due to the printing or copying. One great advantage of this stereoscopic method to the surgeon is that by simply shifting the right picture to the left and the left picture to the right after the first view he can reverse the view and thus inspect the same body *from both front and back*, and be better able to judge of the relative distances and positions of the objects."

Frame for Plate.—A necessary device in the taking of stereoscopic radiographs is a means of exchanging plates without the slightest disturbance of the part which is being exposed. Make a substantial wooden frame large enough to admit the plate. It may be about two inches thick. Across the top of it, stretched like a drum-head, cover a light-proof parchment. Make the floor movable, and with small blocks so as to receive the plate always in one situation. When the plate is inserted have the floor lift by a lever so as to raise the plate to close contact with the parchment. The arm or part resting over the parchment remains stationary after the first exposure while the floor is lowered, the first plate removed, the second plate inserted, and the floor raised again and the second exposure made. If a cross of fine cotton-wrapped wires is tightly stretched over the centre of the parchment, it divides the plate into four quadrants in the radiograph with the centre at the point of intersection, and over this point the tube is focussed with a plumb-line. If the wrapping of these wires is freshly wet with marking ink the impress will mark the skin of the patient coinciding with the shadow of the wires on the negative. If these markings are not desired in a given case, omit the cross wires.

The Tube-Carrier.—In making a stereoscopic radiograph it is necessary to shift the tube in a special manner, and this requires a horizontal bar parallel with the cross-wire marking the centre of the plate, and fitted to two uprights which are adjustable over the patient. This bar is fitted with a spirit-level, a tube-holder, a centimetre scale, and adjustable stops. A scale runs from zero in the centre to each side. The cross-bar can be raised or lowered as desired on the upright posts and the sliding tube-holder can be shifted to any part of the scale. The displacement of the tube for a stereoscopic picture is usually three centimetres on each side of the centre. The displacement must always be horizontal to the plate and parallel with the equator of the plate.

Stereoscopic Exposing Device.—An apparatus for taking stereoscopic radiographs has thus been described by Gregory:

"This apparatus was devised to give with ease and celerity the actual position of a foreign body or injury to the bones of hands or feet, etc., by viewing a picture taken stereoscopically on a single plate.

It consists of a base-board on which is placed a platform of card-board eleven inches in length. This is supported on each of its longest sides by wooden strips a half inch thick, thus forming a sort of tunnel through which a sliding carrier fourteen inches long of thin wood can be pushed easily from side to side. This has stops on it to keep the plate in position centrally. The card-board is protected by tin plate for four inches at each end, thus leaving three inches clear in the centre. In this portion five straight cuts are made partly through the board in which are imbedded fine No. 36 copper wires a half inch apart. In a line with the centre wire is placed a wooden pillar with a joint level with the top surface of the card. This has adjusting screws so as to limit the side screen of the pillar to the width of the eyes at about ten inches above the joints. There are holes in the pillar to take corks as tube-holders so as to vary the distance from the object.

"In use, the focus-tube is placed in position so that when the pillar is vertical the platinum plate is square with the centre of the three inches clear space on the platform of the part to be taken. The plate is put in its place on the slide and shifted to the left so that the ends of the slide and the platform coincide, and the pillar is inclined to the right. The current is turned on for the requisite time, and stopped, the position of the slide and the pillar reversed and another exposure made. The axis of the rays is thus kept pointing to the centre of the platform. We shall thus obtain on the plate images of the bones, etc., and also of the wires which serve as a base-line as seen with the right and left eyes, and all stand out in relief in the stereoscope. The apparatus may be made much larger to take thicker bodies and larger plates, to be used with a reflecting stereoscope. The carrier can, of course, be made as a dark slide. One of the difficulties experienced is to give the two exposures the same density and clearness in the negative, but expert operators can succeed well enough for practical purposes."

Examining Stereoscopic Negatives.—When the surgeon has read exactly how to make a stereoscopic radiograph of a part and has successfully put the instruction into practice, what will he do with the finished pictures? As the ordinary parlor stereoscope is useless, how shall he examine them?

It is possible to so train the eyes of an expert that stereoscopic vision becomes an acquired faculty of sight; but while so few possess this knack of visual focus the aid of a pair of mirrors solves the problem. Take two squares of ordinary mirror glass about five inches wide and long, and join them at one edge with an adhesive muslin hinge so that they will fold shut or open to a right angle. Set this piece on a table in front of the eyes so that the angle faces the median line of the nose, and the mirrors diverge equally at the sides. Hold the pair of pictures so that each will reflect in its own mirror. Adjust them to distance and position so that the two finally register as one.

For exhibition of stereoscopic pictures or for more complete examinations by the surgeon a frame for the mirrors and means of supporting the pictures is useful. Such a frame may be finished in various ways. The side pieces for the pictures may be flat, or made to take one or a series of pictures. The frame shown in the photograph was brought from London by the author in 1898, and was made to exhibit four pairs of pictures in a series by simply turning round the square pillars at the ends. The pictures may be held up against the sides by the examiner, and rapid inspection made of any number of pictures; or, to show a class or for general display a set of four pairs is tacked on the sides and examined in turn by revolving the pillars on their pivoted base. (See Plates No. 85 and 86.)

To inspect a given pair of stereoscopic pictures with this appliance after they have been placed in equal positions on the opposite sides of the frame move the apparatus so that an equal light will fall on each picture. It may face a window, or, an electric-light just behind and above the examiner's head is efficient. Now, with each hand draw up the side pillars till they approach to an equal distance from the mirrors at a point where both nearly register in line. Then slide backward or forward the post holding the mirrors till they focus to suit the eyes. When both adjustments are complete the two pictures will show as one and the shadows will no longer appear flat, but will show the full rounded contour of the part.

CHAPTER XXVII

THE STANDARDIZATION OF SCIENTIFIC X-RAY TECHNICS

The Problems Presented.

The importance of placing X-ray work upon a basis of uniformity is patent to every one. When Chairman of Committee on Standards of the Roentgen Society of the United States, the author presented a list of requirements, with a request to members for suggestions. In the Spring of 1901, this list was personally mailed to between 200 and 300 special X-ray laboratories, hospitals, and prominent private operators. It at once appeared to be the universal opinion that nothing about X-ray work could be standardized or formulated upon a methodical basis. This view was a striking comment upon the attitude of the medical profession toward methods of precision. While convenience might well be assisted by an agreement among makers upon various mechanical details of apparatus, yet the basic problems presented to aid uniformity in results and eliminate careless and haphazard methods commonly employed, are mainly:

1. The correct position of the tube in relation to the photographic plate and patient. The author's Position-Finder settles this problem.

2. Immobilization of the part after it is correctly placed for the exposure. Reasonable ingenuity can accomplish this except as to the heart.

3. A standard distance of the tube from the film. A set of correct distances for thin and thick parts of the body with reference to the least distortion within the diagnostic field, is automatically supplied the operator by the author's Divergence Chart and a standard distance for a standard exposure can be adopted.

4. A means of knowing the "defining efficiency" of the radiance in order to determine the time required for the exposure. The author's Penetration Gauge enables this to be done at the time of the exposure, with almost no complication or delay.

5. A system of landmarks to be printed on the plate to aid identification, localization, interpretation, and prove the position and dis-

tance of the tube during the exposure. How well these are supplied may be judged from our chapter on Landmarks.

6. The photographic problem presents the first and final difficulty. However great may be the variation in emulsions and in developing processes, yet uniform adoption of similar X-ray plates (the best obtainable at a given time) and skilled treatment of the negative, would certainly permit a great advance on the average work of the past four years. It is not, however, the author's purpose in this writing to attempt more than the instruction of the beginner in the essential details of X-ray work so as to best improve his individual results. The formulation of standards of technique is properly the function of the Roentgen Societies of the World. The adoption of certain fundamental standards would not, however, require the individual operator to do all his work by arbitrary methods. The standards would afford *means of comparison*, of *aiming at the best results*, of *going into court in a medico-legal case supported by the highest usage*, and *protection* against charges of inaccuracy, injury, or other results alleged to be due to defective technique or malpractice on the part of the operator. The surgeon who conformed to the rules of technique officially agreed upon by the leading Roentgen Societies would be greatly fortified in his defence of a suit incited by a speculative lawyer.

The replies received by the author in respect to the formulation of standards showed that none of the profession grasped the true significance of his purpose. One and all seemed to regard the suggestion as the pursuit of a fanciful ideal which could bear no relation whatever to practical work. A few years more may advance the average of X-ray education, and the pioneer efforts of the author, abandoned for want of co-operation, may yet bear fruit.

CHAPTER XXVIII

"X-RAY BURNS"

General Information. Treatment. Cases. Risk of Patient in Skilled X-Ray Examinations. Similar Effects without X-Rays.

The discharges from an X-ray tube of *high* vacuum and over ten inches from tissues have little tendency to set up dermatitis. In ordinary radiographic or fluoroscopic work for the purposes of *diagnosis* the time required to develop even traces of action on the tissues is from ten to fifty times the length of modern exposures. The "risk" of a proper X-ray *examination* is infinitely less than the readily accepted risks of anæsthesia. It is less than the risk of a trolley ride.

A tube of any vacuum held much nearer the tissues than is the rule in radiographic technics but which has been common in X-ray *therapy*—say from eight down to two inches from the tube-wall—will cause tissue changes which slowly pass through stages of irritation, inflammation, ulceration, and necrosis; depending on the nearness of the tube, the amount of current, the excess of exposure-time, and the degree of impaired vitality of the tissues. This dermatitis may be developed to severe and slow-healing effects by cumulative exposures, or may be as mild from single long exposures as a brief sunburn.

In 1896-97 about 100 cases of all degrees were reported. Then with improved apparatus they became (in diagnosis) practically obsolete. Out of several million radiographic exposures scarce any "burns" occurred. But X-ray *therapy* was investigating their actions and began to cause them purposely as a counter-irritant in certain skin diseases. Therapists resumed what diagnosticians had discarded, to wit: low tubes, short distances, and long exposures. For a time dermatitis was thought to be essential to a "cure." Then reports of even better results were made by men who sought carefully to avoid the dermatitis effect. Medium and high tubes, moderate exposures of not over fifteen minutes, and distances of from six to ten inches enabled operators to treat patients with all the benefits and none of the annoyances of earlier methods which aimed at an inflammatory reaction as a road to cure. The use of metallic coverings on the part with holes cut to fit the lesion also gave general protection from currents that irritated, but with other doses of current no protection was needed and no precautions were required to prevent dermatitis. The heavier the current the greater its capacity to set up dermatitis with a given tube and distance. This rule applies to both Static and Coil currents.

The parts most susceptible to X-ray dermatitis are those thinly covered with muscle, and those having growths of hair. Bony prominences where the nutrition of the soft parts is poor and the surface has the dry resistance of a hairy skin have suffered most. The back of the hand, the eyelids, and scalp are typical examples. The dry resistance of the hair and nails renders them a prey to the irritant action of discharges which pass smoothly through tissues of better conductivity. Impaired vitality or a local lesion may furnish a focus of inflammatory action. *Exactly similar dermatitis has been reported when no X-rays were generated in the tube, and also when no tube at all was connected.* But no case has ever occurred when no electric discharge was present. Painless at first and with slow development varying from three to six or ten days after the initial exposure the deeper lesions have been slow to heal and have acted much like some galvanic burns. The conditions under which they have most appeared have been:

1. Low tubes.
2. Heavy currents.
3. Long exposures. Or, frequently repeated exposures with cumulative effects.
4. Tissues near to tube-wall.
5. Susceptibility of the tissues. (A previous irritability.)

When it is desired to avoid dermatitis the conditions to be observed in diagnosis are:

Medium or high vacuum tubes.

Twelve or more inches between the tube-wall and the nearest tissues.

Short exposures. (Less than fifteen minutes; usually under five minutes.)

These simple measures insure exemption from accidental dermatitis. The action from several short exposures closely following each other is nearly equivalent to that of one excessive exposure. Therefore do not repeat long exposures after a first radiographic failure in less than a week. Sufficient account of the character of different degrees and stages of this low grade of inflammation is contained in our therapeutic reports and needs no further description here.

Treatment.—Preventive treatment, in addition to the employment of approved technics, is usually interposing a grounded sheet of some thin metal called a protecting screen, as described in our section on "screens." Or, to protect their hands men who do continuous work with X-rays wear gloves and keep the hands as much out of the field as possible. As dry or hair-covered skin loses much of its resisting quality when wet with a hot solution of bicarbonate of soda; it is recommended to lay a wet cloth or towel smoothly over the part during the radiographic exposure when irritation is feared. The part itself may first be shampooed, and the towel then wet in the soda solution the same as for a galvanic application and laid on the skin.

For the simple erythema, which may develop after considerable exposure and gives warning to halt before deeper effects are caused, a simple emollient to keep the skin soft and a cessation of X-ray work will usually suffice for treatment. Mr. Kinraide, however, finds the following method immediately abortive: At the first sign of erythema, say on the operator's hands, fill two small pails nearly full with water as hot as can be borne. Add a table-spoonful of bicarbonate of soda to each, immerse a hand in each pail, and let them soak in the alkaline solution till the water cools, or about twenty minutes. This has sufficed to at once relieve the effects. For the dry atrophic state into which the fingers and nails of workers sometime get the negative galvanic current should, on theoretical grounds, do much to restore normal nutrition, but the author has had no case occur in his own practice and hence cannot speak from actual test. The negative galvanic current in a very small amperage is a powerful stimulant of healing processes.

For accidental dermatitis occurring in patients there is no specific treatment, but such indications as appear in the given case at the time seen must direct the care. The experience of a number of surgeons who have encountered the lesion in its more severe forms will instruct us:

"The X-ray dermatitis is very painful in some of its degrees and heals with difficulty. The slight forms are affected by applications of dilute lead-water lotion. Among the various remedies that have exerted some influence in the severer forms are zinc oxide, ichthyol, and boric-acid ointment with ten per cent. of lanoline. The pain of the severest form is relieved by an ointment containing fifteen grains of antipyrine to the ounce." (Leonard.)

"In a severe eczema of long standing resulting from X-rays, in which other remedies had failed, good results were obtained from applications of nitrate of silver in strong solution." (Dunn.)

Butler reports having used on one incipient case a fifty per cent. ichthyol and lanoline ointment, with boric-acid. Also a boric-acid eye-wash for the conjunctiva which was involved. In another case which had blistered the ointment did not suffice. The patient began to suffer considerably and orthoform was used locally. The other treatment was about the same as is used in other forms of ulceration, peroxide of hydrogen, balsam of Peru, Castor oil, and various drying powders, which last seemed to give the most relief. The patient tried pretty much every form of dressing.

Another more severe case with burning, itching pain was first treated with I and L ointment; after that by drying powders, covered with gauze and rubber-tissue. Moist dressings of gauze wrung out in hot carbolized solutions and covered with rubber-tissues, cotton, bandages were soon substituted. The wound seemed to be healing rapidly. Orthoform succeeded better than other things to control the pain. The patient was then away two months, using various ointments. On his return the surface of the ulcer was covered with the thick, dry, leather-like, necrotic membrane that seems to be associated with the final stage of burns of this degree. Hot applications and poultices failed to soften it. The following ointment was then applied daily, and almost immediately began to soften up the membrane.

℞ Lead Plaster ....6 drachms.
Cosmolin ....2 "
Salicylic Acid ....10 grains.

Each day some of the membrane of softened necrotic-tissue was trimmed away. It was difficult at times to tell how deeply it could be cut without pain to the patient, as occasionally, tissue that was black and apparently dead would bleed and cause great pain. The ointment seemed to give great relief. In a month and a half the membrane was about gone, and hot moist dressings were resumed. With a week's preliminary treatment with the hot normal salt poultice, eight skin grafts were made on the spots which promised best results. This was repeated in five days, with a total of seventeen grafts. The Reverdin Method was employed. The only dressing was the normal salt poultice, and over this a hot-water bag, which is a great help in skin-grafting, as it furnishes the very needful heat, and also makes slight pressure at the same time. Fifteen of the seventeen grafts "took" and seemed, as they often do, to act as a stimulus to the healing of the skin from the edges. The patient recovered entirely. After citing ten cases in all the author concludes:

"Proper treatment hastens recovery considerably, contrary to statement of Moullin and others. Burns of the first degree are benefited by the continual application of ointments, especially those having a lanoline base. Various ointments and drying powders increase the amount and thickness of necrotic membrane in burns of the third degree. Hot, moist, mildly antiseptic dressings, used early in burns of second and third degree, help to limit the extent of ulceration, and used later, help to hasten the process of repair. Skin-grafting at the proper time is indicated, contrary to the teachings of some."

Another author remarks: "There may be lancinating, peculiar pains, a sensation of heat or cold, prickling, sometimes anæsthesia and analgesia. The implicated areas may remain hyperæsthetic for a length of time with a diffuse erythema or dermatitis. The process begins as a red spot with circumscribed macules or vesicles, vesico-pustule, or a pustule, accompanied by itching and burning. They rapidly develop and increase in size. The destruction of tissue is sometimes superficial, but more often through the entire cutis and even subcutaneous connective-tissue, forming an ulcer. The tissues and effused grayish necrotic matter about the focus of inflammation perish; the peripheral areas become vascularized and are finally converted into granulation. The capillary loops at the base of the ulcer may be red, bleed easily, and are very sensitive. A crust may form and be removed; the lesion may remain stationary. It takes time before a surface of healthy granulation is established. We may make three clinical subdivisions:

"1. Simple superficial inflammation of the skin.

"2. The acute attack upon the skin and deeper tissues, producing a partial effect upon the peripheral extremities of the vaso-motors and spasmodic contraction of the blood-vessels, followed by immediate relaxation and renewed nutrition of the cells. Antiseptic treatment indicated.

"3. Sequelæ of an acute attack, with much destruction of the skin and tissues. In this, with more ulceration, there is more pain and tenderness, superadded to an increase of unhealthy granulation. It will not yield to any dressing. Cleanliness, local rest, and later, massage twice daily, are of inestimable value in maintaining good circulation.

"Under the local-rest treatment an acute attack will in due course begin to subside. The pain, tenderness, and redness will become less. If at this period the lesion be touched it will be found that, although the ulcer looks better, this is not the case with the tenderness. Some spots will be found which are not in the least tender; others where the tenderness is extreme and seems to be linear along the site of a nerve-trunk distributed to the periphery affected. Injured parts are more susceptible than normal tissues." (Jicinsky.)

These cases of severe lesions are now rare and have not come into the author's practice, but from a resumé of the reported indications it would seem that selected applications of electricity could well meet them all, combined with ordinary surgical care. The relief of pain, sedation, arrest of suppuration, improvement of the local blood supply, promotion of healthy granulation, all come well within the simplest resources of scientific electro-therapeutics, and if applied early should also act as a prophylaxis. Theoretically the remedy fits if dosed according to the indications. As said before, the galvanic current in small dosage with the negative pole is one of the most energetic promoters of nutrition in atrophic states, and static electricity can also be so administered and dosed as to remove pain, allay irritation, heal ulceration, improve the local blood supply, start up nutrition, and greatly stimulate repair. In a mild case of pigmentation, superficial inflammation of the skin with itching, pains, stiffness of the skin, drawing tightness, etc., apply a cooling and sedative negative static breeze from a fine brass-point electrode on the bare surface at close range. It will remove the pains, stiffness, and irritation almost at once. The effect is excellent and can be repeated as necessary. When the surface is nearly convalescent a few fine sparks will quicken recovery. The sinusoidal current has also been employed with excellent results in suitable conditions and has great value.

As it is superfluous to repeat here any of the extensively described cases published in early medical journals we may illustrate enough for the purposes of practical information by citing the only two cases which occurred during our war with Spain. They are taken verbatim from the official report.

"Case 1.—Severe X-ray burn by coil. Thomas McKenna, Company C, Sixth U. S. Infantry, gunshot fracture of upper third of right humerus at Santiago; excision made of upper part of humerus. About five months later an attempt was made to radiograph the shoulder to ascertain the condition of the bone. An exposure of twenty minutes was made with a coil actuated with dynamo-current, with a low tube ten inches from the shoulder. No result. A second and third trial was made on successive days, but the tube was so poor that no satisfactory picture could then be obtained with it. Six days after the last exposure slight redness of the skin appeared on the chest and shoulder. The erythema increased, and two days later small blebs appeared. These broke, and small ulcers formed which gradually spread and coalesced. The tissue necrosis deepened and extended, and was accompanied by marked pain and hyperæsthesia. The inflammatory action continued until the lesion covered nearly the whole right breast. Treatment of various kinds was tried, but the greatest benefit was derived from continuous applications of lead and opium lotion. The burn showed no signs of healing for four months. After that time it gradually grew better, but so slowly that the healing process was not complete till eleven months after the first appearance of the lesion.

"Case 2.—Slight X-ray burn with the Static machine. Walter C. Booth, radiograph attempted to discover calculus suspected in pelvis of left kidney. Exposures of twenty-five minutes each were made on three occasions two days apart. Five days after the last exposure an erythematous spot appeared on the left side of the abdomen. This gradually became pronounced in color and spread. There was hyperæsthesia of the part, but no ulceration occurred, and the irritation disappeared in about ten days leaving no sign."

Risk of the Patient in Skilled X-Ray Examinations.—To the more recent graduate whose X-ray experience is but beginning and does not recall the discussions of 1896-97 the question may occur as to which type of electrical apparatus is most liable to cause irritation; and also as to how much the whole risk amounts to anyway. Let us see.

As to the question of apparatus: In proportion to the relative number of each employed the few accidents have been impartially divided between them all. For instance, the total number of "X-ray burns" reported during the Spanish-American War from the seventeen equipments of the army was two—one from a coil and one from a Static machine. "In each the exposure was prolonged and frequently repeated, and the tube was refractory." But the causative factor is not so much the kind of current used as the bringing of the tissues into *close range* of an "*over-dose*" of a "*heavy*" current (of *any type*) discharged through any tube. Passing the static current through Leyden jars gives it more of the quality of a heavy coil current, but the state of the tube seems to influence the cause of dermatitis more than the current *per se*. Yet the tube has no such influence unless the part is exposed near enough to be within the field of this action, and beyond ten inches the action rarely occurs with any tube or any current.

Now as to the general liability of the patient exposed: During the first five years following Roentgen's discovery we may estimate that fully 10,000,000 X-ray examinations were made throughout the world. Perhaps the real number is double this. It can only be estimated. But out of this great total the entire number of "burns" reported in diagnostic exposures have hardly been 200. The serious lesions have not numbered 100. Among the many who make regular use of the X-ray and have reported that in 2,000, or 3,000, or more, examinations they have had no case of injury to a single patient it will be sufficient to quote two surgeons.

"I exposed a feeble child five years old to the rays for forty-five minutes at a distance of sixteen inches. In the months of December and January nearly 600 eyes, representing every nature of disease causing blindness, were exposed to the X-rays. No ill-effects were noted in any case, and many were exposed at six inches for ten minutes.

"Exposure was made for twenty minutes at twelve inches distance upon women in the first, second, and third months of pregnancy with no observable effects, and the maternities at regular term were normal.

"A hen laying eggs was exposed to X-rays several times at six inches, for fifteen minutes at a time. The hen set on nine of these eggs. During incubation the hen and eggs were rayed for fifteen minutes at six inches from the tube. All the eggs hatched and the chicks appeared normal.

"Any substance capable of shielding the body from the electrical actions but pervious to the X-rays and not interfering in the least with their free passage through the body prevents injury and provides a reason for the conclusion that the X-ray itself has no harmful properties. With all that has been written in the lay press, medical journals, and scientific publications, I am unable to find a rational conclusion for the belief that the rays called X-rays ever injured in any instance human tissues." (Editor *American X-Ray Journal.*)

"Since Roentgen pointed out that non-conductors when traversed by the X-light may become conductors, the task of ruling out the electrical effect is not a light one. What I do wish to call to the attention of your readers is this: that *practically*, in careful hands, there is no danger from the use of the X-ray *to the patient*, and very little to the operator. The facts on which I make this statement are these: That in the last five years about 8,000 exposures in over 3,000 cases have been made at the Massachusetts General Hospital *without a single case of X-ray dermatitis in the patient.* That at the Children's Hospital, in the last eighteen months, we have made about 1,000 exposures in over 300 cases, without a *single case of dermatitis in the patient.* That in the last five years, in my private practice, I have made nearly 1,000 exposures without a single case of dermatitis in the patient. The sum total is about 10,000 exposures in 4,000 cases without one case of loss of hair or burn of the skin.

"As far as danger to the operator goes, there is no question that a serious dermatitis extending into the deeper layers may be set up. At times my own hands have had the typical appearances of a slight grade of this form of burn, but they have never been excoriated nor cracked, nor so severe that I could not go through the ordinary permanganate preparation for surgical operations. I attribute this freedom from trouble to my habit of never exposing myself near the tube if I can possibly help it. I take no other precautions. One severe case of maiming dermatitis I have seen, in a gentlemen whose enthusiasm outweighed his prudence, but the value of whose work has almost compensated for the sacrifice.

"I seek the opportunity of mentioning these facts in your columns because I believe that the comparatively small number of unfortunate cases which have been published have circulated much farther than the immense number of fortunate cases, and have given the profession the idea that the process is a dangerous one *to the patient.* The fact that the X-ray is in daily use in the large hospitals without harmful results should be put in blacker type than the rare exception.

"E. A. Codman, M.D.,
"*Surgeon to Out Patients, Massachusetts General Hospital;*
"*Skiagrapher to the Children's Hospital.*"

The two factors, skill and caution, always of value to the surgeon, will reduce the liability of accident to a minimum in each and every use to which the X-ray can rationally be put. In almost all cases of X-ray burn reported the tube has been nearer than eight inches from the tissues, often only three inches, sometimes less than one inch. Some of the early injurious exposures were from one to three hours. With good apparatus and technic no short exposure at even the shortest radiographic distance has set up any degree of dermatitis. In skilled and careful hands it may be claimed that *a tube is practically as little danger to a patient as a camera.* To make this true in fact should be the aim of all physicians.

Similar Effects without X-Rays.—*The American X-Ray Journal* in August, 1897, published an article on "X-Ray Injuries," by Dr. Scott, of Cleveland, O., which at the time was the most careful resumé of the subject that had been made by an impartial and earnest investigator. In directing particular attention to this article the Editor mentioned certain tests of his own which had caused the same dermatitis *without* X-rays. He said:

"I made a chain of twelve Grecian sponges tied together with cotton string. The first sponge was united to a No. 32 wire six feet long. The other end of the wire was hooked to an exposed electrode of a Crookes tube incapable of generating X-rays. The current was from a High-Frequency coil excited from the alternating street current. In the test the current divided just as it would do in a live tube and passed with considerable resistance to the twelfth sponge, which was (by the aid of an insulating handle) brushed over and near the thigh of a paralytic. Tests resulted as follows.

"After a time sensation was perceptible, and later a dermatitis appeared. The experiment was repeated with a tube giving X-rays, with the same result.

"The same result is obtained if the wire is coiled about the tube.

"If the skin is exposed to any point of the wire connecting the strand with the Crookes tube the result is the same.

"If the skin is exposed to the tube while an electric current passes the effect is the same, and it is not modified by the direction of the anode."

"At a recent meeting of the Vienna Society of Physicians, Dr. Schiff and Dr. Freund reported an interesting action of high-tension currents on the skin. According to the authors (says the *Lancet*), when the hairy skin is exposed for twenty minutes to the silent discharge of the negative pole of a powerful Ruhmkorff coil, such as is used for the production of the Roentgen rays, the hairs commence to fall out, the hair bulbs become atrophied after the third exposure, and some days later the portion of the skin which had been exposed becomes perfectly bald. The hair follicles become red and inflamed after the first two exposures. These observations seem to prove that depilation can be produced by the action of high-tension currents, and that the depilatory effect of exposure to the Roentgen rays may be accounted for in this way."—*Electrical Review*, 1901.

At the meeting of the Roentgen Society in December, 1900, Mr. Kinraide stated that he had personally suffered all the effects of a bad "X-ray burn" from making a series of coil experiments with a very powerful coil without any tube or any X-ray apparatus whatever in use. The author can produce very similar "burns," varying from slight erythema to deep ulcers by passing any considerable static current to the tissues through a sufficient dry resistance. Many seem to be unaware that this can be done.

Conjunctivitis and Incipient Retinitis from X-Rays.—Operators subject to long-continued exposures suffer some from irritability of the eyes which can develop into inflammation with sufficiently intense cause. Sherer reported such a case in a physician who had been daily exposed to the action of X-rays for three years and a half. He first suffered from photophobia and eye-fatigue. Later conjunctivitis developed. The histories of several similar cases have been given. Read also our report of case exposed to intense arc-light in section on Phototherapy. The obvious protection for operators using X-rays and finding trouble with their eyes is the same as that employed in phototherapy. The chemical rays are nearly stopped by plain clear white glass, and the physician who does not wear glasses for visual defects can avoid irritation during X-ray work by wearing a pair of large plain glasses without focus.

NOTE.—The author prepared a full description of the various theories regarding X-ray burns; but, as some fifty pages of text were thus taken from more valuable matter, it was deemed best to omit the further discussion of burns.

CHAPTER XXIX

X-RAYS AND FRACTURES

General Studies. Differential Diagnosis.

It was from the first obvious that X-rays ought to impart information about fractures, but owing to reliance upon a *plane* shadow taken by transmitted light too often *without traversing the fracture line,* the great bulk of negatives made by non-experts (whose name for the first five years of radiography was legion) the impression got abroad that X-ray information was not reliable. On the other hand, experts, accurate though few, aligned the part in the essential mechanical relation to the axis of the rays, adjusted the factors of the exposure, and reported results that at once awoke skepticism.

Owing to the general need of knowing what aid in diagnosis to expect from X-rays, we shall carefully review the best opinions available. In studying these reports we must bear in mind that they refer solely to examinations made with *a single focus,* and that such work is but the infancy of the fuller development of technical methods held out to the profession in stereoscopic effects. However slow it may come, the day will come when X-ray examination without *binocular perspective and form* will be deemed as unworkmanlike as auscultation of the lungs through an overcoat. Still, we must here consider the routine of to-day.

A new treatise devoted exclusively to fractures thus summarizes the application of ordinary radiography to this particular branch of work:

"The greatest usefulness of the rays thus far is in the recognition of fractures. With their aid accuracy takes the place of ignorance and doubt, and painful manipulations cease to be necessary for diagnosis. Nor do they merely confirm knowledge already gained. Even the most skilled experts in fractures are unable to deny that owing to swelling of the soft parts and obscurity of symptoms there are many bone injuries the true character of which could not formerly be discovered by an examination. The number of cases of fracture formerly mistaken for sprains, contusions, or displacement was enormous. It is in such cases that a simple glance with the fluoroscope

PLATE 89.—This plate illustrates the rare splitting off of part of the outer table of the head of the tibia, including the upper tibio-fibula articulation. The injury was sustained in hunting. The rider was thrown from his horse, while his leg was jammed tight between the horse and the side of a ditch. (Rebman, Ltd.)

The author desires to call attention to the special lesson to be obtained from the series of radiographs that follow. They are reproduced here, not as fine examples (though they were extremely fine in the originals), but to teach the reader that the ordinary radiographic prints of medical journal articles on X-ray work are nearly worthless as diagnostic illustrations. Compare these with your own finest negatives and see how the quality of diagnostic value has been lost in the presswork. Study these as warnings against judging radiography by presswork copies instead of fine originals, and realize the great difference between electrotype and negatives.

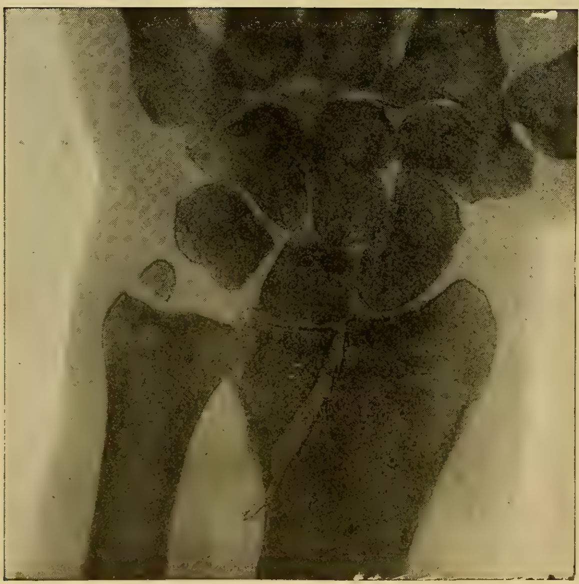


PLATE 90.—Fracture of radius and ulnar styloid. In examining these reproductions the reader will learn much from a careful study of such definition as is still poorly retained in the half-tone. The markings of the joints between the small bones tell the expert very nearly the position of the tube when the exposure was made and evidence is given of the shortness of the exposure-time. (Rebman, Ltd.)

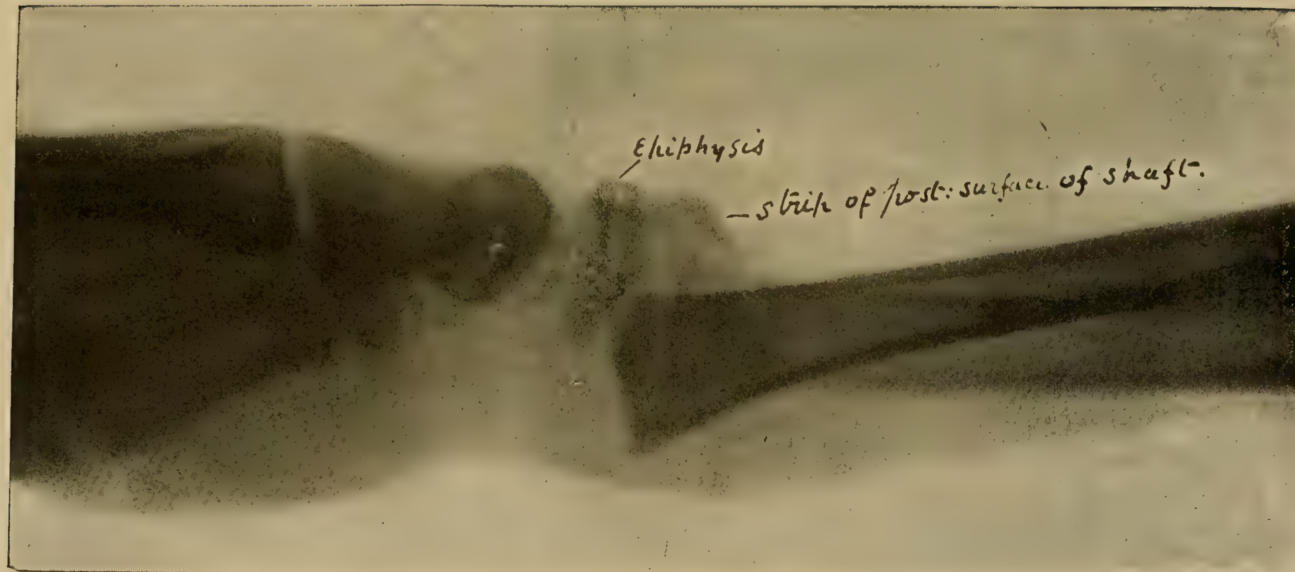


PLATE 91.—Colles' fracture with backward displacement of the shaft of the radius. An antero-posterior view of the same case which is not here reproduced shows separation of the ulnar styloid apophysis.

PLATE 92.—A Fractured Patella. Radiographed two days after the injury. (Rebman, Ltd.)

often furnishes precise evidence. Whether there is comminution, or impaction, or the intervention of muscular tissue, or intra-articular fracture, or fracture combined with dislocation, can at once be clearly determined.

"If the picture be fixed on a photographic plate the nature of the injury can be studied at leisure, and the proper line of treatment decided on without subjecting the patient to any tentative manipulations. After a dressing is applied the X-rays can verify the proper position of the fragments. In short, the proper execution of all therapeutic points can be verified throughout the course of the case, the dressing, even if a plaster splint, being no obstacle to the rays. If the therapy proves to be imperfect the rays show the nature of the condition. It is easily determined, for instance, whether an ankylosis be fibrous or osseous, and consequently the question of indications—whether the breaking up of adhesions or resection—can be settled at once. Even the shoemaker can profit by the X-rays, which will prove whether shoes fit accurately—an item of great importance in the after treatment of fractures of the bones of the feet and in club-foot."

"It is needless to call attention to the frequent importance of a skiagraphic proof in court for the protection of the surgeon as well as of the patient. The greatest benefit obtained from the rays in the proper judgment of the various types of fractures is in connection with those situated in the neighborhood of joints. The special uses of X-rays in diagnosticating the various types of fracture may be grouped as follows:

"Fractures of the *clavicle* are, in general, easily recognized without the rays. Still there are rare cases of infraction and fissure in which no deformity or crepitus is observable, and which could not be recognized except by the aid of the rays.

"In fractures of the *scapula* the conditions are often so obscure that without skiagraphy the true nature of the injury may be veiled; for instance, when dislocation of the humerus is combined with fracture of the acromion. In fractures of the *humerus* it is the shoulder-joint and elbow-joint that require the use of the rays most frequently. Especially in reference to the elbow-joint it may be safely asserted that an exact diagnosis without skiagraphy is simply impossible in by far the great majority of cases. Skiagraphy will infallibly demonstrate the various types of elbow fractures; it will furthermore show whether the line of fracture is transverse or T-shaped, and whether there are any complications, such, for instance, as a fracture of the olecranon combined with dislocation of the radius.

"In fractures of the *forearm* it is the elbow-joint and the wrist-joint that especially require the use of these rays. In these cases, as well as in those previously noted, a large number of new facts have been revealed, which have entirely revolutionized our pathologic and therapeutic views.

"Fractures of the bones of the *hand* occur much more frequently than was formerly supposed. Fractures of the individual carpal and metacarpal bones, and even of the phalanges, were often mistaken for contusions.

"Fractures of the *pelvis*, the accurate recognition of which formerly offered the greatest difficulties, can also be readily demonstrated—the differentiation between contusion, fracture of the acetabulum or of the neck of the femur, and dislocation especially coming into question. Most valuable information can also be obtained as to the presence of impaction.

"In fracture of the *femur* it is not only the hip-joint that may require the use of the rays, but also the shaft and lower end of the bone. In the neighborhood of the knee-joint rapid swelling often absolutely prevents an accurate diagnosis except when the rays are employed. Furthermore, in all the different intra-articular complications the occurrence of epiphysial separation, and the question as to the transverse or oblique or T-shaped line of fracture can easily be settled.

"Fracture of the *patella* can easily be recognized without the aid of the rays. Still, there are some important questions—for instance, whether there are several fracture lines or whether the fracture is complete or incomplete—that could not be determined without the aid of X-rays. *It goes without saying that in the proper determination of the after treatment, in the correct restoration of the fragments, and in the confirmation of the result in the event of wiring, skiagraphic control is simply indispensable.*

"In fracture of the *leg* the difficulties were often insuperable before the discovery of X-rays. It is especially in the malleolar type that serious disturbances are observed. Particularly in regard to *Pott's fracture* many fresh facts were revealed by the rays, so that, just as in fracture of the lower end of the radius, our views have been changed completely. The number of fractures of the *ankle* formerly treated as sprains and dislocations, to the great disadvantage of the patient as well as of the surgeon, is legion.

"Fracture of the *foot* is also found to be more frequent than was formerly supposed. Individual fractures of the tarsal and metatarsal bones and of the phalanges were often erroneously taken for contusions. It has been found that the so-called œdema of the foot, so frequently found among the German infantry, is always due to a badly united fracture of a metatarsal bone.

"In fracture of the *ribs* and of the *sternum* skiagraphy will often prove to be useful from the stand-point of jurisprudence.

"In fracture of the *vertebræ* the exact location of the fragments is of great importance in determining the advisability of operating.

"In fractures of the *skull*, those of the face and of the inferior maxilla have derived the most benefit from X-rays. Fractures of the base are still with difficulty demonstrated. In fracture of the larynx the question of differentiation is easily settled by the rays." (Beck.)

The value of X-rays in the examination of fractures would appear so obvious to lay readers and mere medical practitioners as to

PLATE 36.—Showing a case of rare dislocation of the metatarsus. Taken at the Sydney Hospital, New South Wales. (Rotonsa, Ltd.)

PLATE 14.—This plate illustrates a fracture of the calcaneum caused by a fall of twelve feet. The man fell through a scaffolding and struck on his feet. (Rebman, Ltd.)

PLATE 95.—An unreduced dislocation of the shoulder with fracture of the humerus. This picture was taken after patient was seen by a local surgeon. Diagnosis of dislocation made, and reduction asserted. Rebman, Ltd.)

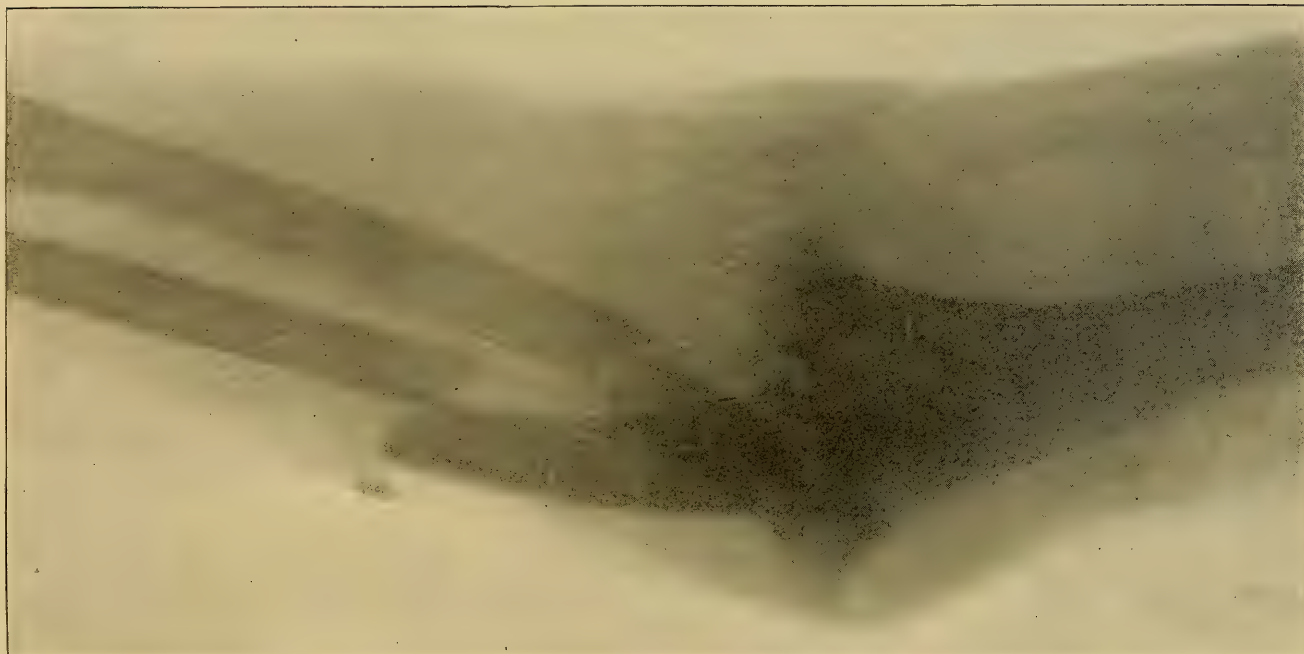


PLATE 96.—Fracture of radius and ulna with dislocation of radius backward. (Rebman, Ltd.)

admit of no controversy, and even the majority of ordinary surgeons welcome their aid and are grateful for their assistance. In peaceful hospital and private practice there are many occasions when an X-ray examination will please the patient better than the pain of manipulations and searchings for crepitus and false motion. In military surgery a writer has said that the X-ray and the Red Cross nurse are the two lone stars in the dark horizon of a wounded soldier.

More than a year ago Professor Von Bergmann of Berlin declared that knowledge of fractures during the last ten years had made *two* important advances. *One* of these was the recognition of the seat of fracture and of the pathological anatomy of the osseous region *by means of the fluoroscope and the radiograph.* The other advance relates to treatment. When the stereoscopic fluoroscope is perfected it will open a new era in the surgical examination of fractures, but the services already rendered by X-rays are too great to be obscured. While the X-rays may be said to be useful in *all* fractures, yet among those in which it is *most* valuable the following are mentioned by Manoury:

"1. Fractures of the upper extremity of the humerus, which so often produce stiffness and ankylosis attributed to peri-arthritis.

"2. Fractures of the lower end of the radius, which frequently accompany lesions of the carpus.

"3. Fractures of the leg, especially those involving the articulation of the tibia and tarsus, in which last radiography is the only means of obtaining exact information as to the relations of the astragalus, tibia, and fibula, a matter of great importance in the prognosis and treatment of these fractures.

"4. Fractures of the astragalus, which some years ago were erroneously considered to be very rare.

"5. Fractures of the metatarsal bone, the anatomical condition well-known to military surgeons, but the cause of which was discussed without being suspected until the advent of X-rays. Radiography is also as useful in the *treatment* of fractures as in their diagnosis, *facilitating reduction*, and enabling the position of the ends to be inspected, and, if necessary, corrected, before consolidation. It also shows in what fractures wiring may be indicated, examples of which are to be found in the elbow and ankle."

Leonard, in speaking of the advantages gained through the use of the X-ray, particularly alludes to the avoidance of much interference with dressings in cases of fractures, and the obtaining of definite and absolute knowledge in fracture examination, without pain or discomfort to the patient. By the X-ray many forms of apparatus to produce immobility have been shown useless. Great variations have been shown to exist from the representations in text-books, enforcing attention to the necessity for careful study of the mechanical elements involved in each fracture. Omitting copies of the pictures, a few reported examples will show the concrete value of X-rays in individual cases.

"Case 1 illustrates the value of X-ray information. A sailor nineteen years of age was injured one week prior to admission to the hospital, by falling from the yard-arm. When admitted, it was found that he had a fracture of the right femur. The part was radiographed to find the exact condition of the fragments. The result showed that the loose fragment of bone had become displaced in a transverse position to the shaft, and in addition to this it was found to be cracked lengthwise. Imagine making this diagnosis without the aid of X-rays.

"Case 2 is the knee of a man who fell from a moving car. He landed on his feet, but on attempting to walk was unable to place any weight on his left leg. A radiograph showed a longitudinal fracture of the head of the tibia. A somewhat similar case involving the opposite side of the head of the tibia, is shown by a radiograph of the right knee of a man who was thrown from a bicycle and sustained a fracture of the inner portion of the head of the fibula.

"Among the more common injuries what is called a 'severe sprain' is one of the most unsatisfactory as far as treatment and diagnosis are concerned. If there is no easily distinguished fracture and no extensive laceration of the muscular and fibrous tissue, the case is usually considered simple. There are, however, many that give unsatisfactory results, have a very prolonged convalescence, and a persistent and sometimes extensive interference with full use of the joints. These latter cases are sometimes classed as cases of chronic rheumatism when seen long after the sprain. A careful study of a number of so-called 'severe sprains' of the wrist that have come under our observation during the past two years, have led us to conclude that many of them are really more or less extensive fractures of one or more of the carpal bones. The case of a young man who fell from a bicycle several days before applying at the hospital, illustrates this. He had hit an obstruction, been thrown from his wheel, struck on the palm of his hand, remounted his wheel and rode home, a distance of fourteen miles, practically without pain. The next day the wrist was getting steadily worse, and he painted it with iodine. This did not relieve the pain, and the following day he consulted a surgeon. When examined at the hospital, he presented a wrist that was decidedly swollen and painful. A careful clinical examination did not reveal any evidence of a fracture. On account of the nature of the accident, the pain and the swelling, it was thought advisable to make a skiagraph, which showed a transverse fracture of the scaphoid, with slight impaction.

"The reason, no doubt, that more of these fractures have not been recognized, even by the aid of the X-rays, is that many of them are

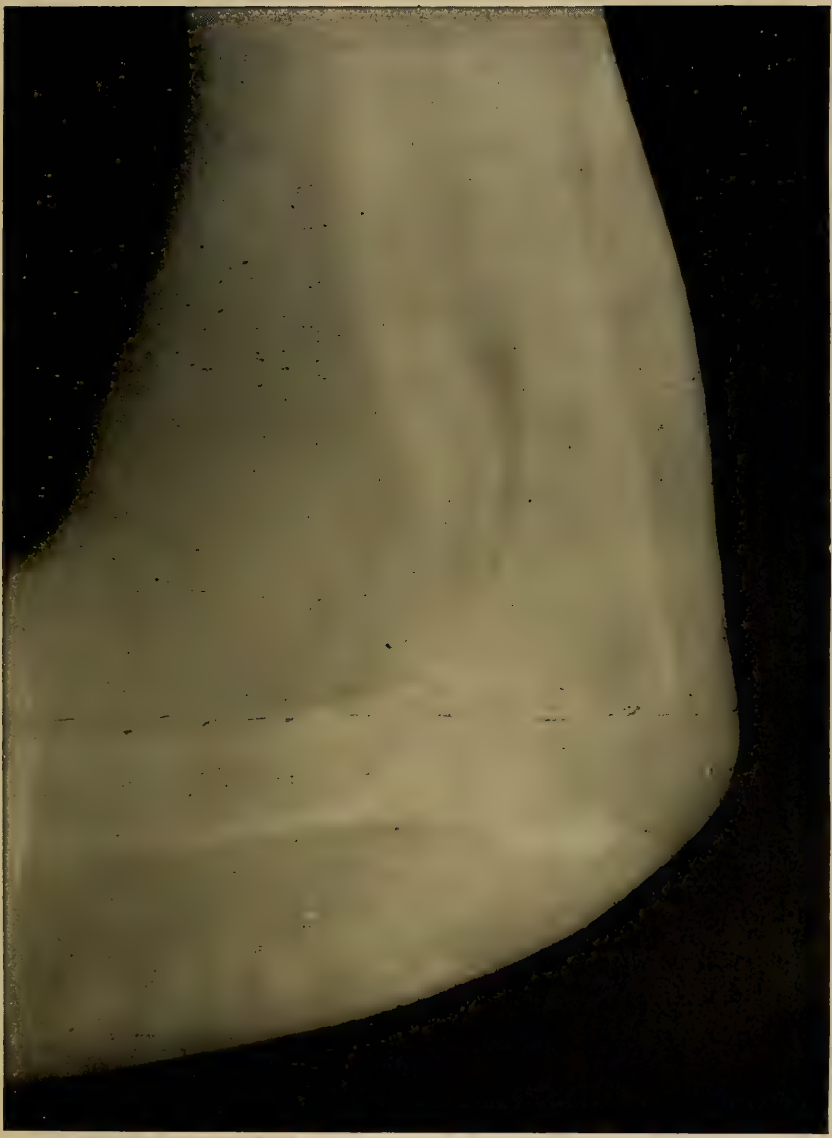


PLATE 97.—A fractured olecranon before treatment. A woman aged 61 fell down several stairs, striking on her elbows. The joint was movable, but flexed, and was so swollen that accurate diagnosis by manipulation was impossible. The radiograph showed the fracture, with about an inch (in the life-size picture) between the fragments. The next plate shows the same repaired with screw. (Rebman, Ltd.)

PLATE 98.—Fractured olecranon after treatment. Ten days after the injury shown in last plate the fragments were brought together and held in place by the screw which shows in this plate. The patient left the hospital in eight weeks and works at the wash tub with the screw in situ. (Rebman, Ltd.)

PLATE 99.—Fracture of olecranon, treated in next plate. (Rebman, Ltd.)

PLATE 100.—This picture shows a fracture of the olecranon treated by wiring. If the reader compares it with the preceding fracture the closer apposition of the fragments appears to be obtained with the screw, but the light space in the wired bone may possibly be filled in by nature with a cartilaginous matrix which will in time become bone. The second of these pictures was taken two months after the operation.

obscure, the lesion not being extensive, and there being little or no displacement. The lines of fracture are more or less hidden, and are seldom easily recognized in the somewhat complicated shadows cast by the normal carpal bones. Even normal wrists may show a slight difference in the development of the various bones, or in their densities. We have seen several cases in which, even after a number of years, no bony union had taken place between the fragments. A case of this kind is apt to be mistaken for a recent fracture unless we take into account the history and clinical symptoms. We have seen in less than three years fifty-two cases in which one or more of the carpal bones had undoubtedly been injured at some time, and in which the patients were at the time suffering pain or were being inconvenienced by the injury or its effects."

"A case of 'sprained fracture' was a man sixty-six years of age, who had been run into and knocked down. The wrist pained, especially on motion, but was only slightly swollen. The radiograph of the left wrist showed the separation of a small fragment of bone from the outer edge of the scaphoid. For comparison the picture of his right wrist was taken, which seemed to show a fracture of the styloid process of the ulna. Upon inquiry it was found that he had sprained his right wrist thirty years before, and the joint was a long time regaining its usefulness."

"The radiograph of another case supposed to have simply sprained his wrist, shows an impacted fracture of the scaphoid. Another case in which the physical examination was misleading, showed a callus on the ulna resulting from a fracture seventeen years before. In another case, presenting an acute arthritis with the wrist much swollen, inflamed, and practically ankylosed, the radiograph showed an old injury to the scaphoid. The patient had 'sprained' his right wrist some time previous, and it had been giving him more or less trouble ever since. The recent arthritis had resulted from the persistent irritation of attempts at use." (WILBERT.)

A Differential Diagnosis.—Owing to the mixed relations of supposed sprains of the wrist, fractures of the carpus, rheumatism, and arthritis, which the X-ray has shown to exist, a study of the differential diagnosis is important. Clinically, the features of a fracture of the carpus may not be definite or well-defined. The history of a fall or injury may be insignificant. It has been repeatedly shown that fracture has resulted from very slight violence. Pain is not diagnostic. The swelling serves often to obscure the diagnosis without presenting any characteristic features. Crepitus is rarely obtained, and deformity may be nearly absent under the mask of the swelling. A fracture of the scaphoid is the most common of the simple fractures of the carpus. It may vary from the tearing away of a slight splinter of bone by the attached ligament to a complete transverse or impacted fracture. Either in combination or alone, the scaphoid, the os magnum, the semilunar, and the cuneiform bones of the carpus have been found injured in cases supposed clinically to be only severe sprains. When fracture of one or more carpal bones accompanies a fracture of any of the related long bones of the hand or wrist, it may be overlooked even in the X-ray examination, unless the entire part is subjected to scrutiny.

But in the case of a simple sprain an adequate X-ray examination comparing both hands under the axis of the rays will show normal bone. If inflammation is present the diagnosis of the nature of the arthritis may be assisted by X-rays. If an ununited fracture or necrosis existed it would show on the negative with a normal condition of the remaining bones and cartilages. A previous history leading to the diagnosis of rheumatoid arthritis would be reinforced if the negative showed ulceration or destruction of the cartilages. The radiograph will be distinguished between an old fracture in the body of a bone and a necrotic process following the destruction of the cartilage surrounding the bone. The more or less clean breaks of the bone with inflammatory exudate surrounding it would indicate a fracture, while a negative showing a more or less irregular breaking down of several carpal bones would point to an advanced case of rheumatoid arthritis. If the radiograph shows a more or less diffusion of inflammatory exudate throughout the carpus when an arthritis is discovered after the prolonged immobilization of the wrist-joint for injury about the lower end of the forearm, it would indicate a not infrequent type of arthritis, which may develop in cases tied up too long with the idea of getting a better union of the fragments. If the examination is not made till long afterward, however, the necrotic appearance on the negative will resemble somewhat a radiograph of an advanced case of rheumatoid arthritis, but the history and the condition of other bones will interpret the diagnosis. It may not be out of place here to say that, both in recent and older cases of any of these conditions, the best therapeutic results may be obtained by certain applications of electricity and motor-massage, full directions for which are given by the author elsewhere.

CHAPTER XXX

X-RAYS IN MILITARY SURGERY

Studies and Conclusions of Experience.

Certain lessons derived from X-ray experience in military surgery contain instruction for the general surgeon who deals with similar injuries in times of peace. The major *lessons* that appear from the Surgeon General's report of X-ray work in our war with Spain will here be grouped for the reader in concise form. Official documents are closely followed.

"During 1898 the United States Army had twelve X-ray coils and five Static machines. When working properly both apparatus produce X-rays of practically equal power and efficiency, but are so utterly unlike in construction and require such different means for their manipulation that they are not under all conditions equally adapted to the requirements of military surgery.

"The use of the X-ray has marked a distinct advance in military surgery. It has favored conservatism and promoted the aseptic healing of bullet-wounds made by lodged missiles in that it has done away with the necessity of exploration by probes and obviated the dangers of infection and additional traumatism in this class of injuries. In gunshot fractures it has been of great scientific value in showing the character of the bone lesions, the form of fracture, and the amount of bone comminution produced by the small-calibre and other bullets—*information which could not otherwise be obtained in the living body.*

"In the treatment of these traumatisms the X-ray has been of great value in determining the course to be pursued, as its use, together with the course of cases under treatment, has shown that the *aseptic* or *septic* condition of the wound is of far greater importance than the amount of bone comminution. This is illustrated by cases of extensive comminution with aseptic wounds which progressed favorably with a minimum of immediate and remote ill-effects; while cases of slight bone traumatism with infected wounds were much more difficult to treat and more serious in results.

"Of the total number of wounded coming under treatment on the American side during the Spanish War the mortality was only 6.64 per cent. In ten other tabulated wars it ranged from ten to fifteen per cent. An effort was made to determine how much of this reduction was due to the use of small-calibre bullets of high velocity and how much to improved surgery. The small-calibre bullet led to conservative treatment in a greater proportion of cases than in the Civil War, and in cases so treated the mortality was reduced from 9.1 to 0.4 per cent. But from the fact that only extremely grave cases were treated by amputation or excision the mortality in operated wounds of the extremities is only reduced from 21.6 per cent. for the Rebellion to 18.7 per cent. for the war with Spain.

"It is concluded that in the classes of wounds showing a marked reduction in mortality in the later war this reduction was related to the increase of *conservative treatment*, yet the increased conservatism was not wholly due to the use of the smaller bullet, for X-ray examinations show that in compound fractures the amount of bone comminution is generally as great with the new missile as with the old. Observations with shrapnel wounds also indicate that slow-moving lead bullets very frequently produce wounds as aseptic as the new bullets of high velocity. The increased conservatism to which seems due the improved results rather than to 'merciful fire-arms,' is, therefore, credited to the recognition of the general aseptic nature of bullet wounds, the use of occlusive dressings to preserve their aseptic state, and the efficiency of antiseptic methods of treating septic wounds. *In enabling the surgeon to preserve the asepticity of bullet-wounds by doing away in many cases with the necessity of immediate exploration the X-ray has played an important part.*

Lodged Missiles.—"Lodged bullets only in extremely rare cases require immediate removal. Surgical interference with such bullets, except where adequate asepsis is available or the necessity urgent, is to be condemned, as suppuration is much more detrimental to the patient than the presence of the missile. In perforating wounds made by the modern bullet the positions of entrance and exit and the symptoms, together with tests made on dead bodies, show that the bullet almost invariably takes a direct course through the part hit irrespective of the tissues, be they soft parts or bone, which may lie in its course.

"In many cases a small-calibre compound bullet which has ricocheted may, from its irregularity of flight, produce an extremely jagged wound. Striking the body while oscillating or turning on its long axis it may cause an external wound of large size and laceration.

"The shrapnel bullet used by the Spaniards was a round, soft-lead ball belonging to the large calibre, low velocity type, and, theoretically, should have produced wounds differing materially from the Mauser. Practically there was not so much difference as was expected, and the wounds which had been given a primary dressing with the first-aid packet generally healed as readily as those made by the Mauser. Reported cases show that in many instances the nature of the missile could not be determined, either by the appearance of the entrance-wound or the sensation of the man, and many shrapnel wounds were thought to be Mauser wounds till the X-ray or removal proved them to be shrapnel.

PLATE 101.—Illustrating Dr. Battersby's Work in the Soudan. This beautiful picture is of great historical and X-ray interest, for it shows the site of the pioneer invasion of radiography into the Soudan. At this point on the Nile, 1,250 miles from Cairo, in a region just rescued from dervishes, the first X-ray pictures ever taken in that part of the world were developed in Nile water looking like thin coffee, and the temperature 110° F. in the shade. Here was situated the advanced base surgical hospital and the headquarters for X-ray work in the Omdurman campaign. Of 121 wounded brought to this hospital after the battle 21 cases could not be accurately diagnosed by ordinary means. In 20 of these cases the X ray found the bullet or proved its absence, and the 21st case was so ill at the time that he was passed. (Rebman, Ltd.)

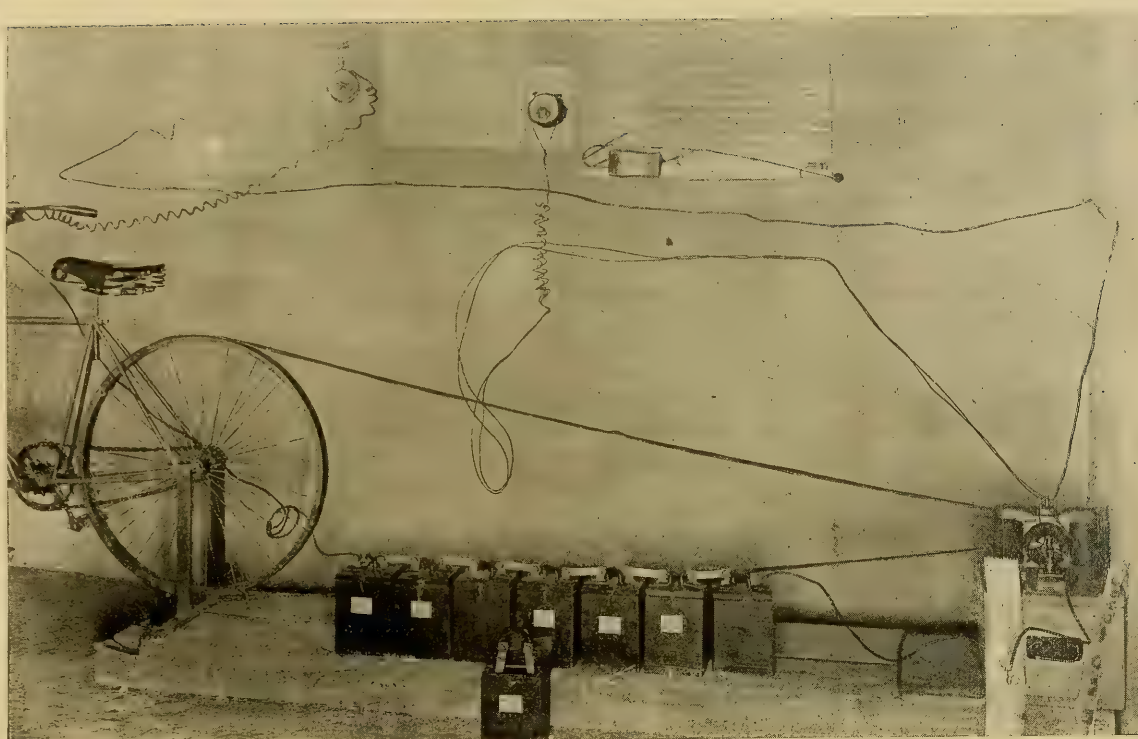


Plate 102.—Plate Illustrating X-ray Work in Military Surgery in the Soudan. Never was the old adage that necessity is the mother of invention better illustrated than in the means improvised in the Soudan to obtain an electric current for X-ray work in a region where little but sand and dirty water could be requisitioned. With an officer mounted in the saddle and the dynamo and storage battery connected, and a shade temperature of 110° F., it was possible to charge the cells. Two men on tandem seats were needed as soon as resistance rose, and owing to infirmities of the installation the labor and perspiration of pedalling were tremendous. Great credit is due to the officer who overcame the difficulties. (Rebman, Ltd.)

PLATE 103.—Plate Showing a Military X-ray Exposure in the Soudan. In this plate is shown the field 10-inch coil at work in the hands of Major Battersby and orderly. Some years hence this picture and its mates will be prized as history and deserve to be taken from perishable current literature and preserved for future readers as the author has done. (Rebman, Ltd.)

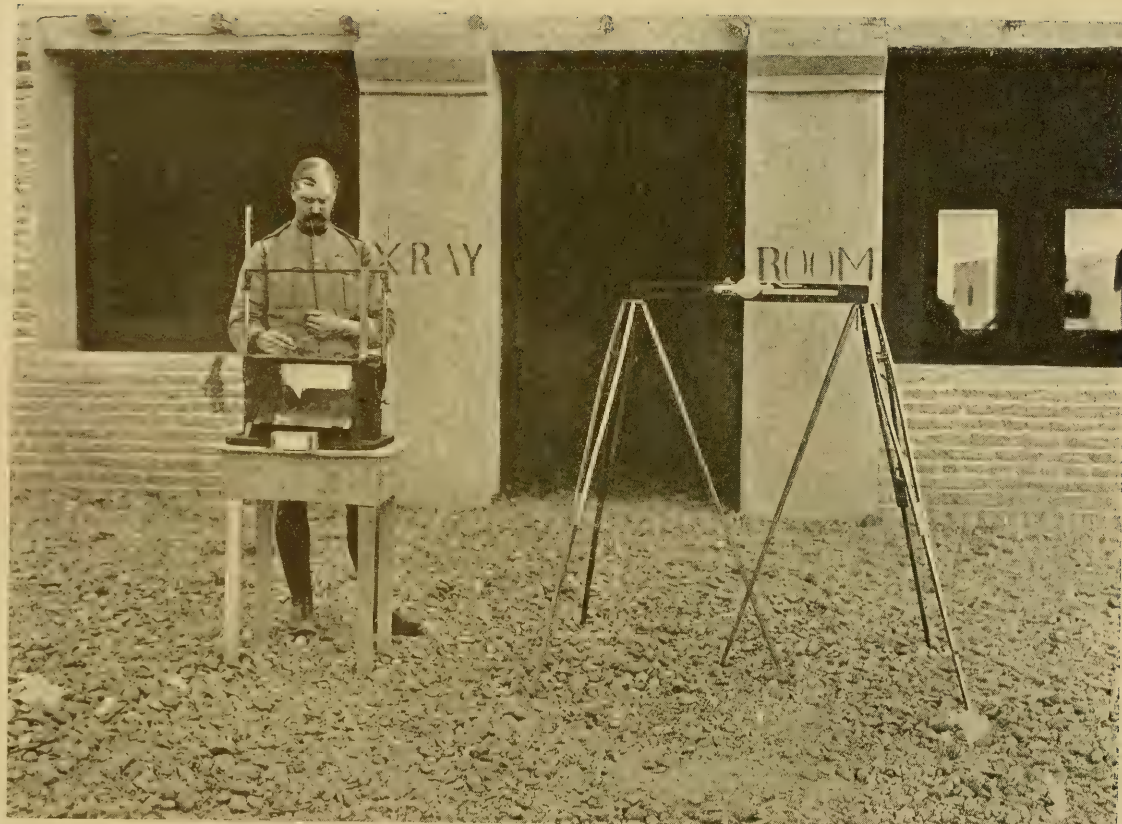


PLATE 104.—Plate Illustrating Localization of Bullet in Negative after Radiography. Here, on the banks of the Nile, is seen the localizing apparatus, a duplicate of which is possessed by the author and by the majority of operators who have done the finest work in this line. The same was employed in the Santiago campaign of our Spanish-American war, and in the war in South Africa. (Rebman, Ltd.)

"These cases are of special clinical value as they show that wounds made by the larger lead bullets, when uninterfered with and treated by occlusive dressing, are usually aseptic and run favorable courses.

"Wounds of considerable size, made by a .41 brass-jacketed bullet with a soft-lead core from the Remington arm carried by some irregular Spanish troops, were either originally infected or extremely liable to become so.

"In gunshot injury of the spinal-cord or brain localization of the lodged bullet will determine whether symptoms are due to the original traumatism or to pressure from the ball." [Three cases of marked clinical interest are reported in full, the X-ray guiding treatment.]

"**Infection.**—While all bullets which lodge would be more likely to produce infection in a wound than those which pass through, yet it appears from the records that *neither ricochet, passage through other objects, lowered velocity, nor contact with foreign matter, the possible carrying of shreds of clothing, etc., into the body, markedly affect the non-liability of the new missile to produce infection.* This is of clinical importance in putting all these wounds, unless manifestly infected, into the class of wounds best treated by occlusive dressings and *non-interference. The same conclusions hold good for the older large lead bullets of low velocity,* as has been stated.

Localization of Bullets in Army Surgery.—"*The superiority of the X-ray over other methods of locating lodged missiles is so great that, when available, it should be used to the exclusion of all others.* It is a most distinct aid to conservative surgery in that it usually obviates an immediate attempt to explore the track of the wound—a necessity before the wound closed, in the old times. The X-ray makes possible one of the great tenets of modern surgery—*non-interference.* The uncertainty and dangers of exploration through the wound are done away with by the certain and safe action of the X-ray, which can be employed at any favorable time.

[Impressive reasons are given at length why the probe in all its forms should be obsolete in favor of the less unreliable and less dangerous X-rays, but lack of space compels us to omit them here.] "Reasons given for X-ray localization, apart from X-ray determination of the presence of a bullet, take cognizance of the fact that lodged missiles frequently become encysted and cause no trouble, but, on the other hand, they may set up suppuration, or press on some neighboring nerve or organ, or may interfere with muscular action, or may cause pain. Moreover the knowledge of the presence of a bullet often creates mental disquiet and anxiety; in other cases it is important to know the exact location of the missile in order to determine whether the symptoms which follow are due to the lesions of transit or to irritation from the foreign body; or whether or not the symptoms may be due to something entirely disconnected with either. In such cases accurate localization is of the greatest importance and value from a standpoint of diagnosis and treatment. (Cases cited.) The X-ray also possesses great value in finding retained fragments of missiles which have been unsuspected till continued suppuration prompts the search." The apparatus used in the army were cross-thread localizers and the fluorometer, the uses of which are both taught in this volume.

"**Gunshot Fractures.**—The results of X-ray examinations made during the late war lead to the conclusion that, minor differences apart, gunshot lesions of the shafts of long bones by small-calibre bullets may be divided into three main classes:

"1. Fractures by bullets having sufficient velocity to perforate.

"2. Fractures by undeformed bullets penetrating only.

"3. Fractures by deformed penetrating bullets.

"X-ray examinations demonstrate that the effect of the modern small, jacketed bullet on the extremities of long bones is markedly different from its effect on the shaft. Owing to the difference in structure the comminution is never so great, and frequently the ball simply channels the bone, or, when nearly spent, embeds itself without any splintering or comminution. The same conclusions relative to treatment, as before stated, hold good in fractures both of extremities and shafts. Infection or non-infection indicates whether the wound should be treated expectantly or otherwise. Nor does the fact that joints are involved alter the rule of treatment. Infection or extensive destruction may necessitate operative interference, but with ordinary penetrating or perforating wounds occlusive dressings and immobilization have been followed by the best results."

A large part of the long report from which the above conclusions are taken is devoted to clinical cases in which the value of all the resources of X-ray facilities grows on the mind from sheer accumulation of the official evidence. Case after case shows certainty of procedure where without X-rays mistakes were unavoidable. One of our chief surgeons wrote within a year that "he knew of no definite addition to our knowledge of fractures or material modification of the general rules of treatment that had been contributed by the X-ray," but practically in the presence of a case the concrete satisfaction of possessing the X-ray outweighs all abstract theories that can be conjured up to deprecate it.

The X-Ray in the Field in War.—At the first hint of war after Roentgen's discovery it was assumed by writers that the X-ray would be a necessity in the *field.* The experience of the Spanish War and the war in South Africa has proved the contrary. In a personal letter from the War Department to the author we have been informed as follows:

"The only X-ray work done during the Spanish War was at base hospitals, such as Key West and on hospital ships. At these places the work was done under the same conditions of posing, apparatus, etc., as is common in city hospitals. There was no X-ray work done in the field, and, I think, fortunately so, for if such work were done

PLATE 105.—A Bullet Wound in Left Ankle Showing Bands of Lead Plaster. Bullet located and extracted. (Rebman, Ltd.)

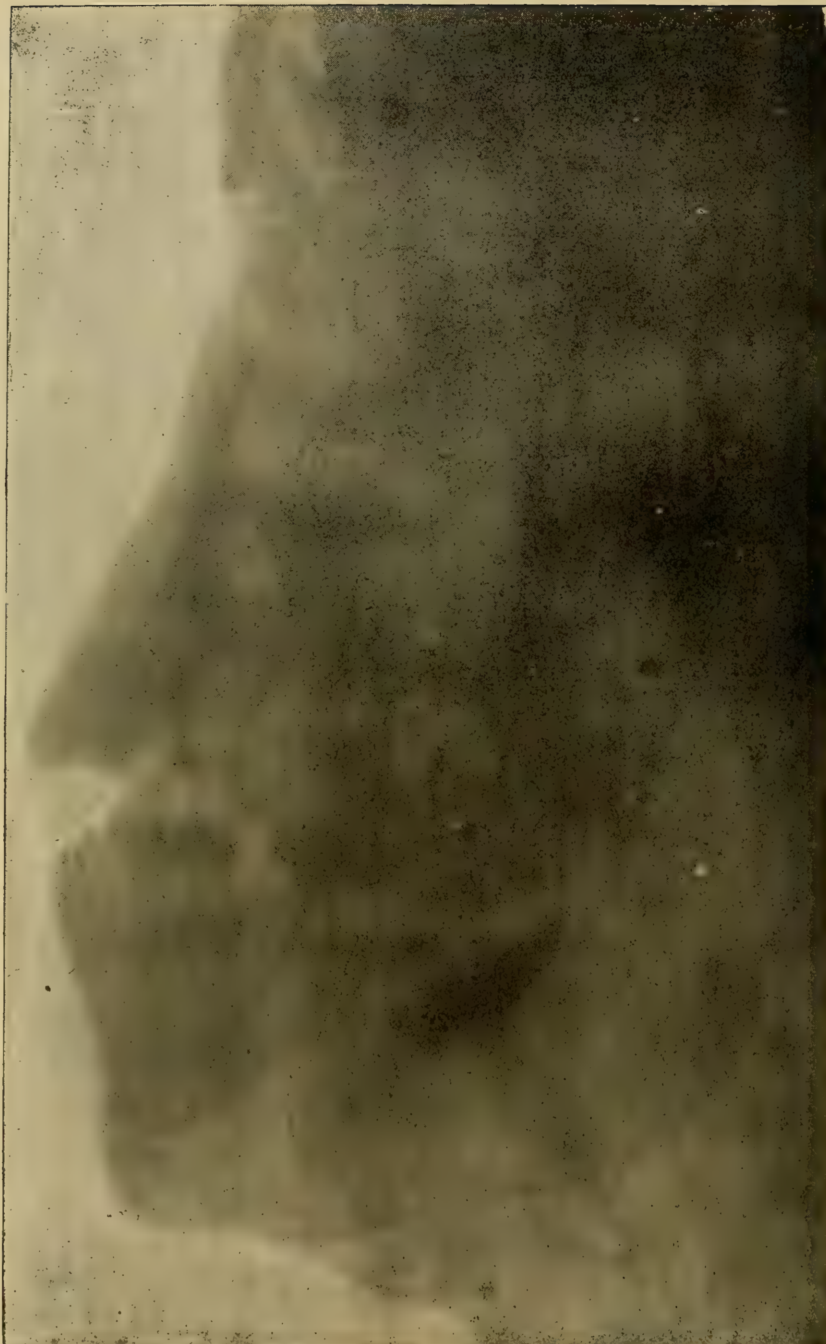


PLATE 106.—Radiograph of bullet located under left lower jaw; entrance wound on right side of neck; removed; jaw fractured; case from armored train disaster; exposure made by Lieutenant Bruce at Ladysmith.

PLATE 107.—This reproduction of a radiograph by Lieutenant Bruce shows a gunshot wound near the head of the radius with fracture of the lower end of the humerus and head of the radius. The casualty occurred at the Wagon Hill engagement, January 6th, 1900. (Rebman, Ltd.)

PLATE 108.—Bullet in knee. Side view. A private wounded in the Soudan. Bullet readily found and extracted. Localization in a case of this kind would be most readily accomplished by the author's "One-Minute Localizer," which requires no negative and but one posture of the part. (Rebman, Ltd.)

in the field it would tempt surgeons to operate without proper facilities for good results. On the hospital ships the surroundings were somewhat novel, but the X-ray work did not differ from that in a city laboratory."

The Surgeon General's report presents the official conclusions on the subject of the field use of X-rays substantially in the following manner:

"The many cases of lodged bullets, in which the bullets were left undisturbed till the patient reached a general hospital or hospital-ship where the missiles were located by the X-ray and removed under antiseptic technic with perfect safety to the patient and rapid recovery prove the non-necessity for the use of X-ray apparatus in field or other advanced hospitals. Infection is almost sure to occur from the almost absolute impossibility of obtaining asepsis under the conditions which are present at the front, and the recovery of the patient is delayed, and the function of the wounded part is likely to be impaired by the suppuration which will follow. Von Bergmann, who obtained such brilliant results in the Turko-Russian War, has expressed the opinion that the X-ray will prove a menace in military surgery if it is allowed to prove an incentive to unnecessary operative interference.

"Professor Kuttner, who followed the Greek War with the German Red Cross Society, states, as the result of his experience with X-ray apparatus in that war, that 'X-rays are of great importance in war, but only for fixed hospitals and those installed in fortresses, while for moving field hospitals their application is very limited.' Abbot also, in an article on Surgery in the Græco-Turkish War, says: 'The use of the X-ray becomes an impossibility at the actual front. Fortunately it is not needed there. In future wars the X-ray will be of the greatest value, but not at the fighting front.' He then formulates in closing:

"'1. X-ray apparatus has no place on the field, where the detection of bullets can only be an incentive to premature exploration.

"'2. The less wounds are tampered with before reaching satisfactory surroundings the better.

"'3. The modern bullet is practically aseptic, and there is no urgency for its removal.'

"Surgeon Major-General Jameson, of the medical department of the British army, says of the X-ray in the Boer War: 'The place, I think, for X-ray apparatus is in the line of communication or at the base hospital.'

"Our experience in the war with Spain was fully in accord with the above opinions, as the use of the X-ray apparatus at general hospitals and on board hospital-ships met all practical requirements. As to the use of X-rays in gunshot fractures the same rules hold as for lodged missiles, to wit: occlusive dressings and non-interference at the field hospitals except when operation is imperatively demanded. Cases of gunshot fractures which can be benefited in any way by the use of X-rays at the front, are extremely infrequent. Also, in considering where X-ray apparatus should be placed for military surgery in time of war the fact must be taken into account that the appliances are more or less bulky, heavy, and somewhat difficult to transport, and that their use requires considerable experience, and at field hospitals would necessitate taking time when surgeons are most busy with the work of active operations. These disadvantages might be disregarded were the benefits in field hospitals at all in proportion to the difficulties of transportation and use; but when the benefits to be derived apply to extremely few cases the surgery of the front can better be employed in other ways.

"In view of these facts it appears that the place for X-ray apparatus is at base hospitals, general hospitals, and hospital-ships, and that apparatus so located will meet all the requirements compatible with the conditions incident to the practice of military surgery. With apparatus so located X-ray examinations can be followed when necessary by proper aseptic or antiseptic operative methods. This plan was adopted in the Spanish-American War with the best possible results."

From the extensive use of X-rays in the South African War it has been the opinion of close observers that they have proved to be *indispensable.* At a comparatively early date in the war the British Government supplied seventeen ten-inch coil equipments for this service, and the greatest experience so far gained in military work has been with these apparatus. A number of official reports suggested improvements; and the place of X-rays in military surgery, and the manner of equipping mobile and base hospitals has been now settled by the combined experience of four wars. Recent revolutionary improvements in storage batteries lessen a serious difficulty of current supply for mobile operations, and if no current is wasted in needless ways a single charge will last a surprisingly long time. The following extract from Catlin's report gives an excellent idea of the range of cases in war practice:

"The cases usually met with consist, in the main, of retained bullets and fractures, though a few cases of traumatic aneurism, periostitis, necrosis of bone and the like, occur. Retained bullets are found in all parts of the body and *can usually be detected with the fluoroscope*, though it is necessary now and then to take a skiagram.

"*The approximate location of the bullet once made out exact localization presents no difficulty, either by means of the localizing apparatus, or, where possible, by taking an antero-posterior and a lateral view.* A short exposure of about four minutes for the thick parts and less in proportion for other situations, seems to give the best results.

"In using the fluoroscope a wide search is often necessary. One patient had a wound of entry just internal to the acromion process

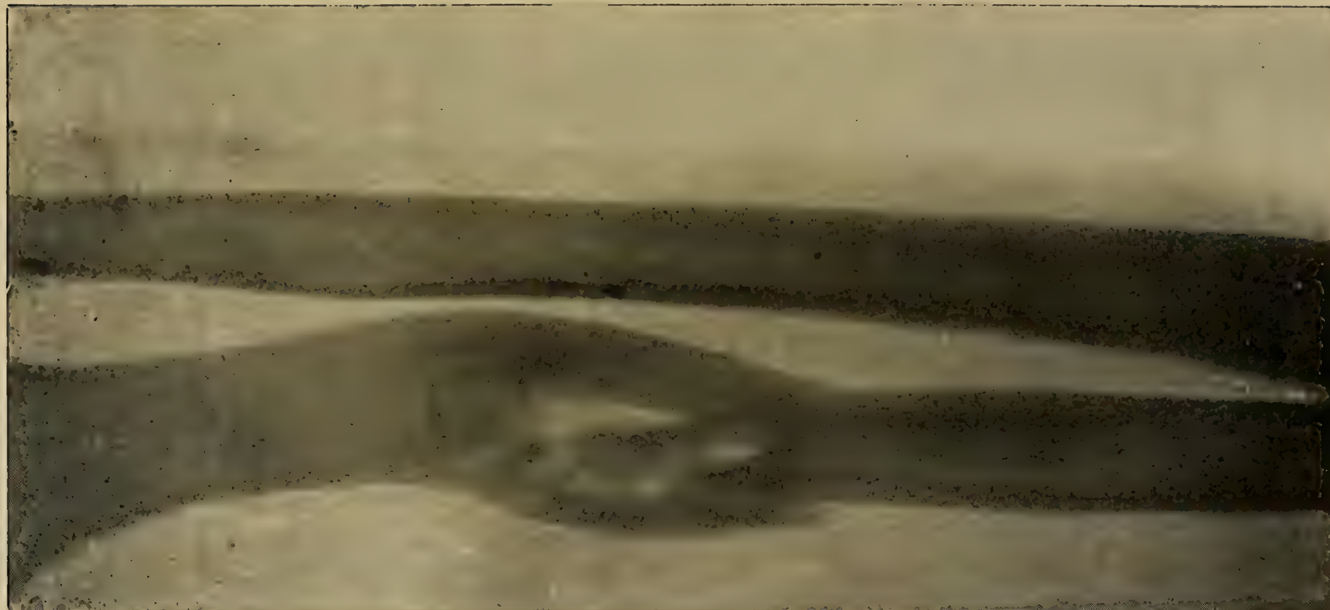


PLATE 109.—A bullet wound in the forearm from the battle of Modder River, South Africa. (Rebman, Ltd.)

PLATE 110.—Splattered Fragments of Lead in Forearm. Minute fragments of shell in the forearm, with periostitis of the humerus. Wounded at Spion Kop, Boer war.

PLATE 111.—This plate shows a bullet in the thigh, but the mass at the upper portion of the print is not a splattered shell. It is dust on the plate and invites attention to the fact that in the interpretation of X-ray photographs the physician's pre-exposure knowledge of what ought to appear in the negative is necessary for the elimination of extraneous shadows. Not even the best expert can fully interpret all the shadows of a plate except in the light of much collateral information.

PLATE 112.—This plate illustrates a gunshot shattering of the upper third of the right femur of an officer of the Imperial Light Horse at the battle of Elandslaagte, in the Boer war. Recovered and returned to duty without amputation. The picture was taken by Lieutenant Bruce. (Rebman, Ltd.)

on the right side. There was considerable bruising down the inside of the right arm and slight bruising of the chest-wall on the right side, but no bullet could be found in the arm or thorax. On examining the body further the bullet was seen lying just above the right great trochanter. There were no symptoms indicating that the bullet had penetrated so far. In another man the bullet entered on the right side of the thorax about four inches below the axilla after passing through the right arm. It was found lying close to the axillary-wall of the thorax on the opposite side.

"A number of patients brought up for examination had what looked like a Mauser wound of entry but none of exit. The symptoms were very like those of a patient with a retained bullet. The fluoroscope, however, failed to show the presence of a bullet, but on taking a skiagram a fragment of bullet little larger than a pin's head was detected. All the patients agreed in saying that the impact felt like the blow of a sledge-hammer, an expression used by patients hit by bona-fide bullets. These fragmentary wounds were supposed to occur from bullets striking a stone and the pieces flying in all directions.

"Out of nearly 400 cases examined here so far the majority are cases of fracture. The difference in effect of the impact on different bones is striking. As a general rule, where there is compact bony tissue more or less comminution occurs. Where cancellous tissue is struck the action is one of simple penetration. In all cases the first action of the bullet seems to be one of penetration; the differences occur after that. Usually in the shaft of a long bone four lines of fracture radiate from the hole first bored, separating the bone into four fragments. These fragments may then break up into smaller ones still, the sizes of which vary with the range—very small fragments at short ranges and larger fragments at longer ranges."

As has been ably expressed by a prominent authority, "The X-rays have furnished the army surgeon with a probe, which is painless, which is exact; and, most important of all, which has aseptic qualities not possessed by the older though ingenious instrument bearing Nelaton's name." In Sudan the conclusion from all observations was this: that each case had to be studied as a special problem with regard to the intelligent adaptation of detail and X-ray method to be employed. A routine system is impossible. "The accurate localization for practical surgical purposes of foreign bodies in the tissues is," says Major Battersby, "the consummation of skiagraphic art. A bullet, for instance, in a loaf of bread can be localized with a fluorescent screen by means of acupuncture needles, but such a procedure is scarcely applicable to patients suffering more or less from shock and in a depressed and nervous condition." Our chapter on Localization teaches the essential methods.

Senn's opinion of the value demonstrated by the X-ray in military surgery has been given various and wide circulation in medical journals, but the permanent record of a few of his remarks should be made in a work of this kind intended for the physician's reference library. As Chief of the Operating Staff with the Army in the Field during the Spanish-American War Senn has written:

"The X-ray has fully answered expectations in military surgery as a diagnostic resource. It has fully demonstrated its great value in military surgery. It may be relied upon in locating bullets in almost any part of the body, and in ascertaining in doubtful cases, existence, location, and nature of fractures, and in determining the exact location of the fragments. All this may be done without pain and without subjecting the wound to additional sources of infection. No ill results followed the exposure in any of the cases.

"The probe, so constantly relied upon in the past in locating bullets, is an instrument of uncertain diagnostic value, and its use is always attended by more or less risk. Modern military surgeons have formulated a rule which should never be ignored, *never probe a recent bullet-wound.* The probe is as objectionable in the examination of a compound fracture as in exploring the track made by a bullet. The X-ray has a great feature in this part of military surgery. The skiagraph enables us to diagnose the existence or absence of fracture in a large number of doubtful cases in which we had to depend exclusively on this diagnostic resource. In fractures in close proximity to joints it has been of the greatest value in ascertaining whether or not the fracture extended into the joints.

"The X-ray also proved of the greatest practical utility in showing the displacement of fragments in gunshot fractures of the long bones, which enabled the surgeons to resort to speedy measures to prevent vicious union. The fluoroscope has greatly enhanced the diagnostic value of skiagraphy in military surgery. In the light of experience the X-ray has become an indispensable diagnostic resource to the military surgeon in active service, and every chief surgeon with every Army Corps should be supplied with a portable apparatus and an expert to use it."

CHAPTER XXXI

X-RAYS IN ORTHOPEDIC SURGERY

SURVEY OF PRACTICAL USES. DIAGNOSTIC IMPORTANCE AND SCOPE. NEED OF BINOCULAR VIEWS IN THIS FIELD OF WORK. HINTS IN TECHNICS.

How great may be the appreciation of X-rays among the general body of orthopedic surgeons cannot be stated, but the scientific and practical value of X-rays in the study of congenital and acquired malformations of the bones would appear obvious. Certainly, if anybody can use X-rays to advantage, it would seem that the specialist with orthopedic practice would find them indispensable. Some of the best and most brilliant radiography yet seen has indeed been done by surgeons in this branch of work, and among them, speaking not from theory but from experience, are men who assert that skiagraphy of the extremities especially has given more valuable information than dissection. The exact anatomical diagnosis which it enables them to make not only defines often the indications for surgical interference, but may also outline the technique beforehand. A dozen names may be mentioned which furnish most brilliant testimony to recent progress in this direction.

But nowhere is seen to worse advantage the limitations of the plane X-ray picture which is the mediocre routine of present methods. The literature of the subject for 1896-99 comprised fully 100 articles, but so far as we are aware all of them dealt with the one-focus radiograph which looks at the part as with a single eye. The superiority of binocular exposures, giving in stereoscopic view the true form, proportion, position, shape, relation, and body of the part instead of a plane shadow without perspective, would be apparent to any orthopedic surgeon at the briefest glance. The fluoroscopic binocular view has a great field here, and if now available in practical form would make obsolete all that has been written of plane pictures, and the radiographs of the past five years would be consigned to the waste basket. For further information on this point see section on Stereoscopic Radiography; also the Stereoscopic Fluoroscope.

With the remark that much that is said about " misleading data " and of *the difficulties of interpretation* refers only to plane radiographs without "body" and does not apply to the far clearer diagnostic pictures made with stereoscopic effects, we select for our instruction two short summaries by skilled men. The illustrations are omitted as cuts of radiographs are unsatisfactory.

Lovett thus writes of the use of the X-ray in orthopedic surgery:

"It is too early in the history of the X-ray to yet speak definitely of its full value or its full possibilities in diseases of the joints. But at the present time it possesses very great value, and in certain cases is indispensable in this branch of surgery. This condition of affairs is so well recognized that many orthopedic surgeons make it in certain cases a part of their routine examination. In general, its use enables us to determine the existence and character of congenital and acquired bony deformities and malpositions. It often aids in the diagnosis of joint disease, especially in tuberculous lesions. It assists when necessary in determining the relations of the bones after operations on the joints; and it enables us to study the history of progressive destructive disease of the joints.

"These are the most frequent practical uses of the X-ray, yet nowhere must the evidence revealed by it be interpreted with greater care and accuracy than in this department of surgery. It is easy (in single-plane views) to see too much or too little and to draw too definite conclusions from yet inadequate experience. At times certain pictures give data that are altogether misleading, but greater practice in technic will lead to better pictures. For instance, an apparently normal radiograph may be obtained in the case of a joint in which tuberculosis is sufficiently active to create serious symptoms. In Fig. 1 is shown the radiograph of the knee of a women aged thirty-five, suffering for many months from an acute, painful affection of the right knee-joint. Tumor albus with abscess had occurred in childhood, and a useful, although flexed and partly immovable knee had resulted. The question as to whether the condition existing recently was due to recurrent tuberculosis or not was most important. The radiograph showed a femur irregular from the destruction of the early disease, but apparently perfectly definite in outline and lacking those characteristics to be described as significant of joint tuberculosis. The symptoms demanded operative interference, and, on opening the joint, an acute state of inflammation was found, and the lower end of the femur was extensively eroded by recent tuberculous foci.

"Fig. 2 shows the same knee in front two months after excision, demonstrating the current position of the bones from that point of view. The estimation by X-rays of the relative size of bones and the relations between them must be accepted with great reservation. The data afforded by such radiographs are *of value only when the relation of the tube and plate are regulated with correct accuracy.* It is easy to produce obliquity of some shadows by a very slight slant of the axis of the rays and very little inaccuracy in this respect on the part of the operator is needed to produce considerable variation in the radiograph."

[Students of this course are fully instructed how to obviate all the above difficulties, and especially to rightly estimate at a glance the relative sizes of bones in all X-ray views of them. The principle is simple and direct.—Ed.]

"Attempts are sometimes made to demonstrate atrophy of one side of the pelvis in hip disease, elongation of one patellar ligament by comparison with the well side, atrophy of one femur as compared with the other, and similar conditions. Success depends on individual conditions and exactness in technic.

"My experience has been mostly with the Static machine driven by a motor and direct 110-volt street current. The highest and best tubes procurable have been used. For the present purpose it is perhaps best to consider not so much what the most experienced observer can see with the best possible apparatus under the best possible conditions, but rather what the average surgeon may expect to see after some experience with such apparatus as he might reasonably have in his office. The photographic plate as a rule, of course, gives the best and most definite information, and often demonstrates conditions which are overlooked with the fluoroscope. A noteworthy instance of this is found in exostoses of the bones of the feet, where exostoses of small size are almost sure to escape detection with the fluoroscope, while in the negative they are easily seen.

"On the other hand, in certain cases fluoroscopic examinations show the most, as for example when it is desired to see the head of a bone in more than one place, as in estimating the relation of the component parts of a joint. For instance, the fluoroscope was more useful than any radiograph could have been in demonstrating the position of the head of the femur in an obscure case of anterior congenital dislocation coming under the writer's observation, because it was possible to watch the head of the femur while the leg was manipulated.

"To secure definition of bones in the radiograph considerable distance between the tube and the part is most important. Twenty inches is a good rule. In the case of young children, and especially infants, the transparency of the epiphyses is an obstacle in many instances to obtaining satisfactory information from the X-ray. The radiograph of the foot of a child of three years old shows the condition at that age. The next radiograph, the foot of a child of seven, shows the ossification at that age. The knee (Fig. 5) of a child of two years makes it very evident that very little is to be seen of the joint surfaces at that age, at least without securing a more differential radiance than the high tubes here used. In one knee may be noted a scarcely perceptible haze due to an acute traumatic effusion, an appearance to be spoken of later. Clearly marked epiphysial lines are seen in the healthy knee of a boy of eleven (Fig. 6), and up to the age of puberty the tubercle of the tibia may often appear to be detached.

"Separation of the epiphysis, however, when it is ossified sufficiently, is easily detected by the rays. In our next picture a boy, after a fall of moderate severity, developed swelling and stiffness of the knee-joint, which, when seen six weeks later, was diagnosed as probable tumor albus after a careful examination. The real state of affairs was made evident at once by an X-ray examination. Congenital bony deformities, absence of bones, and similar conditions can, of course, in children of sufficient age be demonstrated with X-rays. Its most frequent usefulness in this connection to the orthopedic surgeon is in furnishing data, perhaps not obtainable otherwise, in cases of congenital dislocation of the hip. Here it is possible to confirm or establish the diagnosis and after operation to demonstrate the reduction of the head of the femur. It is also possible to differentiate in this way (in doubtful cases) between fracture of the neck of the femur and chronic disease of the hip-joint.

"Coxa vara may be recognized in radiographs. In diseases of the joints the X-ray is most useful in furnishing diagnostic information often not obtainable by other means. Synovitis, if of sufficient degree, is made evident by an increasing resistance to the passage of the rays which surrounds the ends of the bones with a slight haze in the negative. There will be seen no loss of bony outline, but simply less distinctness than normal. In the fluoroscope the bones fade in dark, clean-cut outline toward the joint surface, which should be distinct. In tuberculosis of the joints it is generally agreed that small foci are not, as a rule, to be distinguished in radiographs. Later in the disease, however, an appearance more or less characteristic is to be seen in the disappearance of the shadow of the articular end of one or both bones. In a negative strong enough to give a definite outline of the bones forming a joint it is very suggestive of tuberculosis or *some process destructive of bone* to find a place where the outline of bone disappears, and is replaced by an indefinite cloudy appearance.

"In Fig. 16 is shown the radiograph of a case of hip-disease three weeks after excision. The radiograph before excision was similar to Fig. 18. Before it was taken *a solution of one part of bismuth and two parts of glycerine was injected into the sinuses to demonstrate their course and extent.* The irregular dark areas are due to this injection. This method will be found useful in shadowing the course and extent of sinuses and abscess cavities.

"In acute infectious osteomyelitis the destruction of bone may be identified and negatives present much the same cloudy appearance as in the acute stage of tuberculous disease. Separation of the epiphyses may be identified as well as thickening of the upper part of the femur. In Charcot's disease we can identify bony destruction and displacement. In a case of the elbow the question of diagnosis between sarcoma and Charcot's disease was only made clear by the radiograph. In arthritis occurring in the joints of bleeders Fig. 22 and 23 show two cases under my care. In both the joint inflammation was active when the exposure was made. One shows only a dark shadow around the ends of the bones, while the other shows nothing definite. Gocht has described from two cases which he radiographed certain definite appearances, such as atrophy of the femur, irregularity of the epiphyseal line, disappearance of the normal joint cleft, broadening of the intercondyloid eminence of the tibia, etc. The same dark cloud is apparent in his pictures as in mine.

"In rheumatoid arthritis, exostoses are rarely identified; changes in the shape of the articular surfaces of the bones are to be seen when they are present; diminution or increase in the ends of the bones may be appreciated, and atrophy and destruction of cartilage is made evident by a disappearance of the normal cartilaginous spaces, shown in the radiograph by apparently closer contact of the bones with less space between them.

"Fig. 25 shows the radiograph of a case where the diagnosis was in doubt between chronic rheumatic and chronic tuberculous disease of the wrist. The radiograph showed a clear bony outline, and inoculation from the fluid of another joint in the same patient was negative as regards tuberculosis.

"Fig. 26 is the radiograph of an adult patient with severe gonorrheal arthritis of the wrist, showing an indistinct area corresponding to the carpal bones, which should be separate.

"In certain obstinate and painful cases resembling flat-foot, *the X-ray serves to demonstrate the existence of spurs of bone running from the under surface of the back of the os calcis, and sometimes from the back of the upper surface of the same bone.* This information is not to be obtained by other means, and is most important in the matter of treatment and prognosis, which is in such cases discouraging. They may be identified when hardly larger than a big surgical needle and not over a quarter of an inch in length, and from this stage they apparently grow larger until they reach the size shown in Figs. 27, 28, 29. They occur in connection with gonorrheal rheumatism, rheumatic gout, and in certain cases where no etiologic factor is apparent.

"This paper leaves out the consideration of many conditions as important as those mentioned in this connection, but it has seemed best to the writer to dwell chiefly on those conditions in which the X-ray in his *personal experience* had proved most often of practical use; and conditions in which its conclusions might be open to question, or in which the necessary information might be obtained by other means, have been avoided.

"It may be proper to add that none of the writer's radiographs shown have been in any way retouched or manipulated—a process always open to question."

Says another orthopedic surgeon:

"The age of the patient is no bar to the use of X-rays. The youngest subject exposed by myself was an infant seven days old. Radiographs of this case show the existence of double equinovarus;

genu recurvatum, dislocation of one hip, and a club hand. Within the past few years congenital dislocations of the shoulder have been more generally recognized. When there is any doubt as to the condition of the joint the X-ray furnishes a ready means of making a positive diagnosis. In lateral curvature of the spine the X-ray enables the surgeon to note the degree of bony distortion, and to determine whether a given plan of treatment has any decided corrective action on the malformed vertebræ. A radiograph will probably be found more reliable than any system of tracings and measurements, as it shows the bones unobscured by the soft parts.

"It frequently happens that slight injuries in the neighborhood of joints produce symptoms that are somewhat obscure and tend to mislead the surgeon. A radiograph affords a means of removing any question of doubt, so that appropriate treatment may be instituted. The case illustrated in Fig. 10 is that of a lad about fourteen years of age, who received an injury to his right leg in a football game. He was disabled for some weeks, and when first seen by me, about two or more months after the injury, he was still suffering from pain and inability to get about without limping. A radiograph made at this time showed that the tibial tubercle had become separated and was still ununited. Under treatment, the symptoms rapidly disappeared, and a few weeks later union had taken place, as proven by another radiograph. Fig. 11 is the normal knee of the same subject. By comparing the two figures the pathologic condition may be appreciated.

"The text-books on surgery dismiss the subject of fractures of the tarsal bones, other than the os calcis and astragalus, with the statement that they can hardly occur except from crushing force. One author says: 'I have never seen such a case except when the whole ankle was crushed.' In the light of modern methods of examination, however, it is proved that this statement is erroneous. In a case that recently came under observation, and which had been treated as a severe sprain for four months, it was found that the patient in simply alighting from a 'buck-board' had sustained a fracture of the scaphoid. Other similar instances might be cited.

"The elbow- and shoulder-joints are particularly exposed to slight injuries, that end in serious disability if not in complete ankylosis. The importance of exact diagnosis cannot be overestimated, for the success or failure of treatment must depend upon it. Slight fractures into or in the neighborhood of joints cannot always be determined with any degree of accuracy even by the most skilful surgeon, as crepitus, etc., may not be elicited. A radiograph, however, may be relied upon, if the precautions referred to in a previous section are resorted to. In one case of marked disability after an injury to the shoulder, where several competent surgeons failed to determine the condition of the bony structures, a radiograph revealed a fracture of the acromion process. In another case of partial ankylosis of the elbow, an X-ray examination demonstrated an apparently insignifi-

PLATE 113.—This Instruction Plate shows adjustment of Author's Examining Frame with ankle-joint engaged in the field of axis-rays. The examiner sits in front with screen clamped in place. It is removed in the plate to show position of tube, the anterior and posterior vertical guides in line and making only one shadow, and the relation of foot to the markers. Note that though the frame is slightly tilted to suit the comfort of patient, yet the correct axis of the rays is maintained. The boy is an orthopædic case, and the white line along the leg is not part of the examining-frame, but a metal brace which he wears.

PLATE 114.—For practice in interpretation study this picture as it is, and then look at it in a mirror with a good side light. The mirror shows it to be a right hand exposed palm down and the deformity is much better studied when the normal position is restored to the observer's eye.

PLATE 115.—A case of false joint and deformity of leg. Age twenty-two. No pain. When three years old the child could run about quite well, and it is suspected that she then sustained a green-stick fracture which was neglected and did not form a complete osseous union. After the X-ray picture revealed the condition of the bones, an operation resulted in a useful limb. The cast shows the leg after treatment, but a second skiagraph is not available to show the actual state of the bones. (Rebman, Ltd.)

PLATE 116.—A gouty hand. Five seconds exposure. When this picture was taken with five seconds exposure the hand was first protected by heavy sheets of zinc till the tube was excited to its best efficiency. Then the zinc was suddenly withdrawn for the exact exposure-time and quickly replaced to cut off the rays abruptly as the tube was stopped. Variations of this plan have been used for other purposes. If it is desired to hold back the action upon the fingers so that the bones of the carpus may receive sufficient exposure a layer of zinc over the fingers during the first half of a normal exposure accomplishes the result. The mere hint will suggest special applications to the operator.

cant fracture of the olecranon as the primary cause of the restricted joint-motion.

"The condition of an elbow illustrated in Fig. 12 is of interest, as it shows the result of a severe fracture of the condyle of the humerus and of the radius and ulna, and demonstrates the cause of the existing disability.

"The value of radiography in deciding upon the advisability of operative or other interference in old bone-injuries, is perhaps not sufficiently appreciated. Patients might frequently be spared the use of the knife, and the surgeon relieved of the disappointment of a useless operation, by availing himself of this aid to diagnosis. This is well illustrated in Fig. 14, which shows a fusion of the patella and femur with fibrous ankylosis in the knee-joint proper. It would have been useless to attempt *brisement forcé* for restoring motion, with the patella and femur so firmly united.

"The differential diagnosis between true and false ankylosis is generally easily established by the ordinary methods of examination. When, however, the fibrous bands are very short, permitting no appreciable motion, some reliable means of differentiation becomes a necessity. A radiograph settles this question beyond any doubt.

"The value of radiography is fully established; it only remains to develop it to its highest possibilities, which must be accomplished by those operators who are willing to devote sufficient time and energy to the study of the subject, and become masters of this new art."

CHAPTER XXXII

STUDIES IN THE X-RAY DIAGNOSIS OF CALCULI

At a time scarce half a year ago, when the majority of active surgeons could not pose a patient nor place a tube for such a diagnosis, the editor of the *Archives of the Roentgen Ray*, himself an expert, wrote these words:

"It is difficult to place too high an estimate on the value of the X-rays in this particular branch of surgery. Exploratory operations for stone in the kidney may now be regarded as things of the past. Not only can a calculus be detected before it has reached any considerable size or has destroyed any large portion of the renal substance, but its exact location in the kidney can be shown beforehand so that it can be removed with the minimum of disturbance."

The scattered abstracts of current medical literature are lost to the surgeon who wishes to read up the subject and a composite gathering of facts in permanent record will here furnish a great deal of necessary instruction. For much of the material which we have revised in compact form we are indebted to Leonard, who has devoted special attention to this technic.

"The development which has recently taken place in methods of physical diagnosis greatly facilitates the differential diagnosis of renal disease, and pathologic processes in other organs can be readily excluded. The centrifuge, the segregator, the urethral catheter, and the cystoscope, are factors which have aided greatly in this development. Added to these is the X-ray. The X-ray method of detecting or excluding calculi in the kidneys and ureters has proved itself to be absolutely accurate when applied with requisite technic. The errors which have been noted have all been due to defective technic or to inexperience in reading the negative. The absolute *negative* as well as the absolute *positive* diagnosis of calculous disease is demonstrated.

"The advantages which this method possesses are its mathematical accuracy, and comprehensiveness; the equal value of the negative and positive diagnosis; the ability to detect calculi in their incipiency before serious injury has been done to the functional efficiency of the kidney, and when the freedom from infection makes an aceptic operation possible. The dangers that threaten when a small quiescent calculus is present can thus be avoided, as well as the dangers of operating upon the wrong kidney; or upon one without knowing that the other is the seat of calculus; or of leaving a calculus behind by an incomplete operation. The operative interference is localized and limited to a very small area, facilitating the operation and avoiding needless injury and traumatism to other portions of the urinary tract. Thus a calculus weighing forty-two grains was located in the upper pole of the kidney and removed through a small incision directly down upon it, that barely admitted a finger. A small ureteral calculus was located just within the pelvic brim, where it was found by bimanual palpation. It was removed by a transperitoneal ureterolithotomy, and proved to be a uric-acid calculus of the mulberry type which weighed two and three-fourth grains. A second ureteral calculus was removed per vaginam. A ureteral catheter was introduced and the vaginal wound packed; both packing and catheter were withdrawn on third day with perfect healing. This ureteral calculus was apparently a phosphate stone and weighed twenty-seven grains. A large calculus of the same character was removed from this patient's other kidney. It was broken and could not be weighed. It was phosphatic in composition, and measured over two inches in length. On the side where the ureteral calculus was found there was a large hydronephrosis, on the other a pyonephrosis. Other cases have been previously reported where encysted calculi were detected, and where multiple calculi were removed and the completeness of the operation assured.

" *Such advantages clearly demonstrate the superiority of this method over exploratory nephrotomy or any other method of diagnosis. It is free from all danger and inconvenience, and is more accurate.*

" The detection and accurate *localization* of the calculus, in cases of unilateral or complete anuria due to calculous disease, is of the utmost importance in directing and limiting the operative intervention. Complete anuria is readily recognized, but the *localization of the seat of obstruction,* although of the greatest moment, has hitherto been a most difficult problem, uncertain of a correct solution.

" The question of unilateral anuria can be settled by the segregator or the ureteral catheter, but calculous disease can only be detected or excluded with certainty by an X-ray negative properly made and interpreted.

" The patient should be given the benefit of such methods of examination before operative treatment is decided on. Without them he is exposed to the immediate danger of the loss of one kidney or to the future dangers that surround the presence of a quiescent calculus in the kidney. The advantages that are to be derived from early diagnosis and operation should never be forgotten. This early diagnosis can be made in all of these cases as soon as suspicion points to the possibility of a calculus.

" The formation of a renal calculus generally takes place without producing any recognizable symptoms. The condition is not suspected until the calculus interferes with the function of the kidney or that of the ureter. This may take place while the calculus is small, or not until it has attained large proportions. The first symptom that usually attracts attention is pain. Either a dull, diffuse ache in the lumbar region, or it may be a severe attack of colic. This is sometimes accompanied by sufficient functional disturbance to produce a slight albuminuria, or a few leucocytes and red blood-cells may be found in the urine. If colic is present, and the symptoms are severer in character, interference with the function of the ureter is indicated. All these symptoms may, however, result from other causes, either intra- or peri-nephritic, and may even be more marked, and yet no calculus be present. The difficulties that lie in the way of an accurate differential diagnosis in the incipiency of this condition are very manifest.

"A short time ago the diagnosis of renal calculus was never made until the classical symptoms showed that the pathological process had so far advanced as to render surgical intervention necessary, and yet hazardous. At that time the diagnosis of calculous ureteritis was never made, and many patients lost one kidney as the result of unilateral anuria, and many others died without any other diagnosis than 'suppression of urine' ever being made. The exact diagnosis of calculous ureteritis is seldom made even now. Many patients suffer the loss of function of one kidney because the impaction of a calculus is not recognized, and the resulting anuria leads to the atrophy and destruction of the affected kidney. The clinical pictures presented by destruction and recovery are identical. If a calculus passes after an attack of renal colic and escapes detection the pain subsides, the urine clears, and perfect function is restored. If a calculus becomes impacted in the ureter the symptoms do not differ apparently. If the urine becomes normal the 'cure' (?) is attributed to this or that internal medication, or the true condition is not suspected, or the attack is attributed to some other cause. The possibility of such an occurrence is readily admitted. The X-ray findings show that it is probably much more frequent than has been suspected. In a series of thirty-six cases detected by the author over fifty per cent. were ureteral calculi.

"Clinical experience shows that other pathologic conditions often simulate calculous nephritis so closely in their symptomatology that an absolute diagnosis cannot be made by ordinary methods. Even in exploratory nephrotomy an expert surgeon is liable to err. This was shown in the case of Taylor and Tripp, and has lately been demonstrated in another case in which a large calculus was not detected by an expert surgeon, who even went so far as to report it as a case 'in which the symptoms were most misleading, as they were typical of calculus, yet none was present.' The radiograph demonstrated the presence of the calculus.

"The mechanical accuracy of this method is very great. Error can creep in only through faulty technic or lack of skill in reading

PLATE 117.—Method for Gall-stone Radiography. This Instruction Plate is remarkable from the fact that it illustrates a successful case during the actual making of the radiograph. Mrs. A. M., age thirty-four, history of acute attacks of cholecystitis. There was marked jaundice, temperature 100° F., pulse 120. Patient weighed 101 pounds, was five feet three inches in height and very thin. Cut shows apparatus and posture for fifth exposure, tube axis passing through gall-bladder at an angle of 60 degrees to avoid liver. Exposure 50 seconds. Two gall-stones found and removed a week later. One was round and contained phosphates only. The other was elliptical with a nucleus of cholesterine with phosphates around. Photographed especially for this Instruction Course by Dr. Jicinsky, whose case it was.

PLATE 118.—Radiograph of Calculus in gall-bladder, verified by operation and removal of stone. Arrow points to the calculus. Despite loss of detail in reduced half-tone the stone shows clearly.

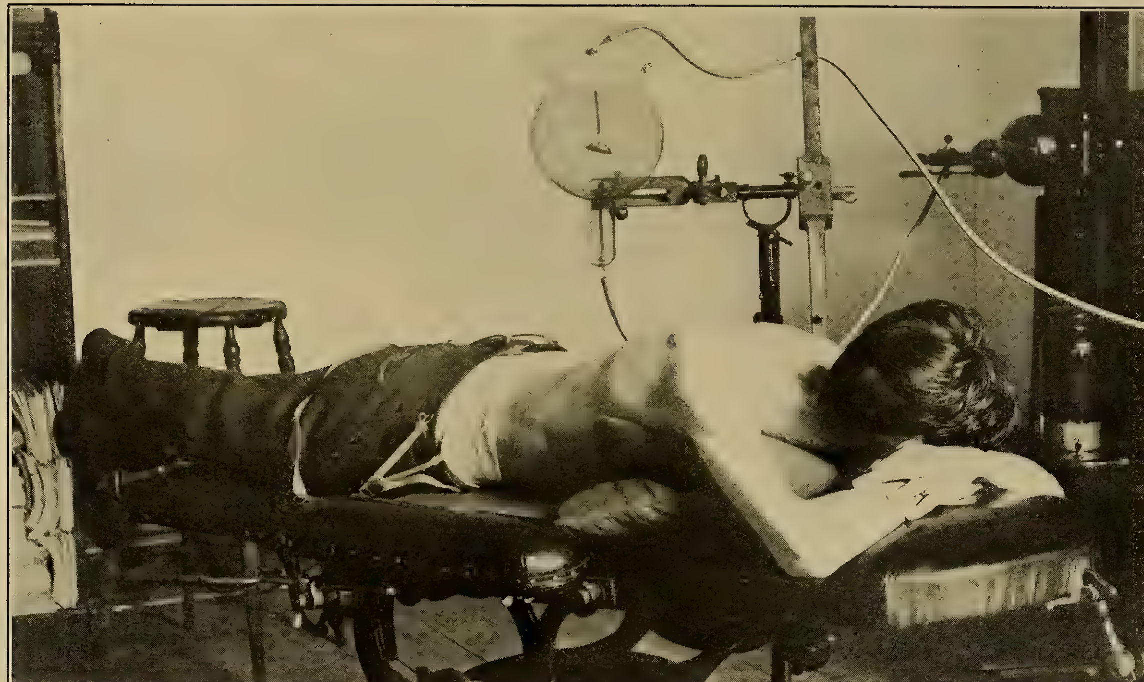


PLATE 119.—Method for Renal Calculus. Case of Dr. Jicinsky. The exposure was five minutes. Large calculus in left kidney found on the negative. Diagnosis verified by operation. The radiograph resulting from this exposure is not reproduced, as half-tones lose so much of the detail of originals. The technic shows so plainly in this Instruction Plate that any surgeon can follow it.

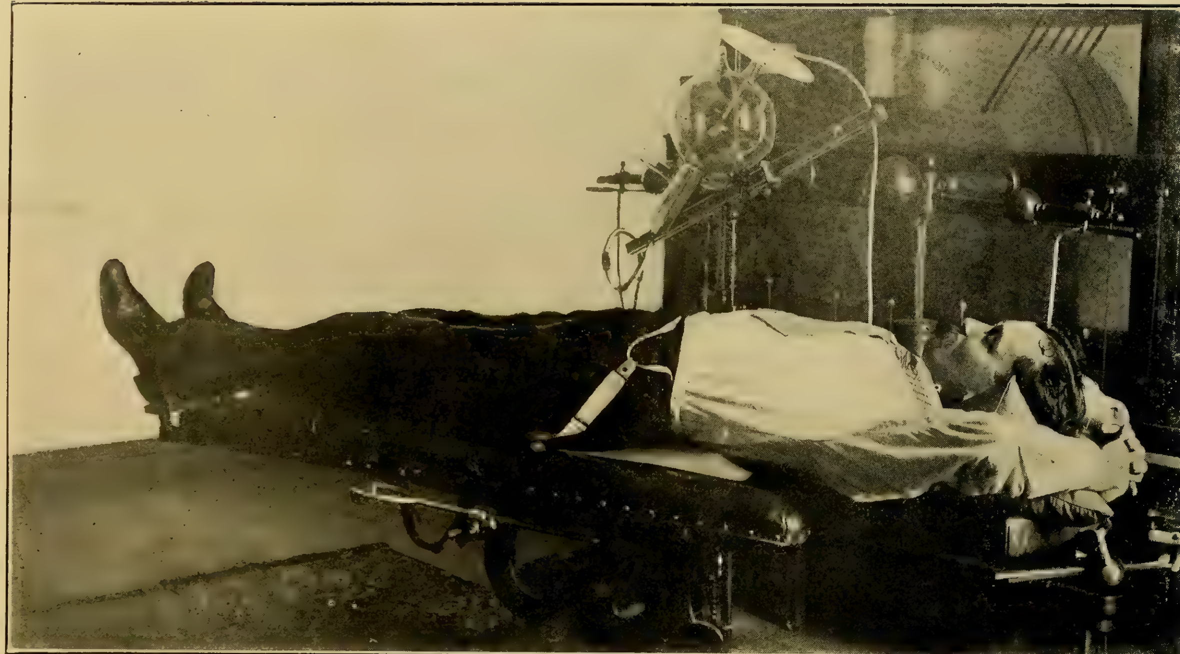


Plate 120.—Method for Renal Calculus with dorsal position of patient. Photographed especially for this Instruction Course by Dr. Jicinsky during the actual exposure of a radiograph which resulted in detecting the calculus. The method is shown so plainly that others can easily duplicate it.

the negative. Where the negative secured fulfils the requisite conditions the experienced eye can detect or exclude all calculi. In some cases, as in very corpulent or muscular subjects, it is not yet always possible to secure a negative with the essential detail, but when the negative is correct the diagnosis is *absolute*. Exhaustive studies by Swain, Ringel, Wagner, Buget, Gascard, and others have shown that renal calculi have varying degrees of opacity to the X-rays corresponding with their chemical composition. Oxalates are the most opaque, phosphates next, carbonates the same, and uric-acid calculi least. Size is more important than composition, and even the least dense uric-acid kind have been well shadowed on the plate. The cases in which the author has so far demonstrated the absolute mathematical accuracy of the method number 165.

" The method is based on the axiom that if rays are employed that will differentiate between the shadows of tissues less dense than the least dense calculus all calculi will be found. The absolute proof of the diagnosis is evident in each negative *when such a differentiation is shown*. If the calculus is there it will be seen, and if none appears on such a negative it does not exist. The production of negatives having these details in the soft tissues of the lumbar and pelvic regions is the only essential to the diagnosis, and is secured by the employment of a large *volume* of radiance having a medium penetration. Experience has shown that the vacuum requisite is equal to one to two inches of air-gap resistance as measured by a coil.* This latitude in resistance is necessary in regulating the penetrating power of the rays to the individual patient. For the same reason the length of exposure varies with the individual, and is also dependent on the amount of energy in the secondary coil circuit. A *heavy current without thin voltage* is the chief factor in producing a large volume of radiance such as is required.

" The only basis on which a diagnosis can be reasonably established is the production of a negative which, in the individual case, visibly differentiates between the shadows of tissues less dense than the least dense calculus. The effect of different doses of radiance on penetration is shown in two pictures. The calculi were laid on the film. The tube was the same in each exposure. The same exposure-time was used. The plates were developed in the same bath for the same time. The only factor that varied was the resistance of the tube, which in one case was a three-inch spark-gap and in the other less than one and one-half inches. The *negative* and *positive* diagnosis are rendered absolute by the present technic, but the operator must be able to show in his negatives the definition of lumbar and pelvic soft parts less dense than any calculi. *One* such negative showing such detail in the regions occupied by the kidneys and ureters is sufficient evidence upon which

* The student will note how much more difficult it is to get an accurate idea of the X-ray dosage employed by the above writer than it would be if the author's gauge tested it. It could then have been stated at once whether the radiance should be X_4, or X_8, or X_{10}, or any other power.—Ed.

to base a *negative diagnosis.* A *positive* diagnosis should always be confirmed by a *duplicate* picture taken on the same day. As in all cases of localization of foreign bodies, operation should follow as soon as possible.

"Bigelow's evacuator is very serviceable in finding small calculi that have passed into the bladder, but no further. An examination with it should always precede operation for the removal of a small ureteral calculus that has been detected by X-rays, especially if an interval elapses between its detection and the operation, or if attempts have been made by massage to dislodge it. This is equally true of all foreign bodies. Operation must follow immediately after the localization or the localization must be repeated. Immobilization is always essential during the interval.

"The rendering of correct diagnoses in cases where the symptoms are indefinite or wanting illustrates the great value of the method. The *positive diagnosis* has, however, a greater value than the simple detection of a calculus. It is more accurate, comprehensive, and precise than any other method. The position of a calculus or calculi in both kidneys and ureters is determined with a precision that limits the field of operation, makes the operation more accurate, and assures its *completeness.* It is no longer necessary to open a hydronephrotic kidney before the ureteral calculus, which is the real cause, can be located. The operation is directed immediately to the ureter. In two cases remaining calculi have been found in the opposite kidney after operation, and in another case a calculus was found in the same kidney previously operated on. Such incomplete work cannot be done after a thorough X-ray diagnosis. Calculi have been present in both kidneys or ureters in four cases examined. This is the only method except double exploratory nephrotomy by which it is possible to exclude calculus from the apparently healthy kidney before a nephrolithotomy or a nephrectomy is undertaken.

"The detection of three calculi weighing one grain or less in the kidney and ureters and their subsequent passage has demonstrated that this method is capable of detecting the most minute calculus in its incipient stage. This is of the utmost value to the patient. These are the calculi that produce complete anuria by occluding the ureters. They are the more dangerous because they produce fewer and less definite symptoms. Morris has said of them: 'If such silent, lurking calculi could be discovered and removed, many deaths from calculous anuria, much illness and suffering from perinephric abscesses and renal fistulæ, and many kidneys undergoing atrophy and degeneration might be saved by well-timed operation.' Statistics derived from the operations of the most competent renal surgeons show that the mortality of nephrolithotomy is but two or three per cent., if the operation is undertaken when the calculus is small and before infection has taken place. When the characteristic symptoms are present and infection has taken place, the mortality rapidly rises to twenty-five per cent. This method assures the detection of all calculi as soon as a suspicion points to their presence, and by their early diagnosis affords the patient all the advantages of an early operation. *The examination is made with no inconvenience to the patient and without the introduction of instruments into the bladder or ureters, and the consequent danger of infection.*

"The value of the absolute *negative* diagnosis by this method is possibly *greater than that of the positive.* It often renders operative intervention unnecessary, and at the same time renders medical treatment rational and not dangerous. The accuracy of the negative diagnosis by skiagraphy has been seriously and frequently questioned. Since claiming that the *negative* diagnosis is accurate, the author has examined 136 cases suspected of having renal or ureteral calculi. A negative diagnosis has been rendered in 100 of these cases. In only one case has that diagnosis been disproved by the operation. In that case the error resulted from a misplaced plate and defective reading of the negative.

"Sources of error lie not in the method, but in its improper employment and interpretation. Experience in developing and employing the various qualities of X-rays must be combined with clinical experience in reading negatives and translating them into diagnosis. This is often the most difficult part of the task, especially when the diagnosis is negative instead of positive. When, however, the correct reading has been determined the plates form a mechanically produced proof that is capable of demonstration. A *negative* diagnosis by this method is the one means by which the *non-operative treatment of suspicious cases can be made rational.* The dangers surrounding the treatment of cases that simulate renal or ureteral calculus, by non-operative methods, are clearly evident from the consideration of the similarity in symptomatology between recovery and the destruction of a kidney by calculous anuria.

"The passage spontaneously of a number of the ureteral and of one renal calculus, after they had been detected, points toward conservatism in operating in certain cases. Such a course is safe and rational where it is based upon the data obtained by this method. The exact determination of the size and position of a calculus makes it possible to estimate the chances of its passage. It makes it safe to wait, as the seat of any operation that may be necessary is predetermined. The presence of infection, the size and position of the calculus, and the previous history will have much weight in these cases. The persistence of pain in the lumbar region and the history of repeated attacks, with the presence of blood in the urine, point to partial occlusion and make delay permissible. A large calculus, the presence of infection, or an absolutely normal urine, indicating unilateral anuria, make immediate operative intervention imperative if the kidney is to be preserved. Such conservative treatment must, however, be conducted under strict surgical supervision, and frequent analyses of the urine should be made. The ease with which such minute calculi slip into the bladder renders it necessary to search for them in the bladder before any operation is commenced for their removal. This precaution should always be observed with small calculi, and the bladder carefully examined by a Bigelow's evacuator while the patient is under the anæsthetic before the operation is commenced.

"The effect of this method of diagnosis upon operative procedures has been marked. The field of operation has been *localized* by X-rays to the point where the calculus is situated. The completeness of the operation is assured by the determination of the exact number and position of the calculi. The calculus can be removed through a much smaller wound in the kidney, with the assurance that no calculi are left behind. Ureteral calculi are attacked directly either by the extra-peritoneal route, by trans-peritoneal ureterolithotomy, and by puncture of the ureter through the vaginal vault. All these methods have been successfully employed in one or more of the cases examined. With the exact knowledge of the location of a calculus, it will often be possible to palpate it, and in especially favorable instances to push it along by massage, or even by crushing small calculi of suitable composition, to secure their removal. From the examination of 136 cases suspected of having renal or ureteral calculi, and the detection of nineteen cases of ureteral and seventeen cases of renal calculus, the author draws these conclusions:

"That both the *negative* and *positive* diagnosis by the X-ray method are accurate and valuable. That ureteral calculus is much more common than has been supposed, or about fifty per cent. of all cases of calculus. That it is impossible to arrive at as accurate a diagnosis of calculus by other methods. That this method is comprehensive, and aids operative intervention by localizing all calculi and excluding calculi from the other kidney. That non-operative treatment, without a negative diagnosis by this method, is irrational and dangerous in cases that are at all suspicious. That this method is precise, because its results are mechanically produced, but that accuracy in its employment and care in reading the results are necessary to the avoidance of error. That the data obtained by this method make non-operative, conservative treatment rational in cases of small calculi low down in the ureter that can be expected to pass. That the negative diagnosis does not preclude exploratory nephrotomy, but does make unnecessary the actual incision into the kidney in search for calculi. The dilatation of the ureter with bougies, as has been practised in the female, may be employed in the male by utilizing a suprapubic cystotomy wound to guide the instruments from the urethra into the ureters." (Leonard.)

From facts in possession of the author it may be estimated that at this date not less than 200 different operators have successfully radiographed calculi of the various forms. This is a great advance on the situation of two years ago, and we may assume that much further progress will be made. Within a few months Drs. Schmidt and Kolisher have reported a special technic which involves the introduc-

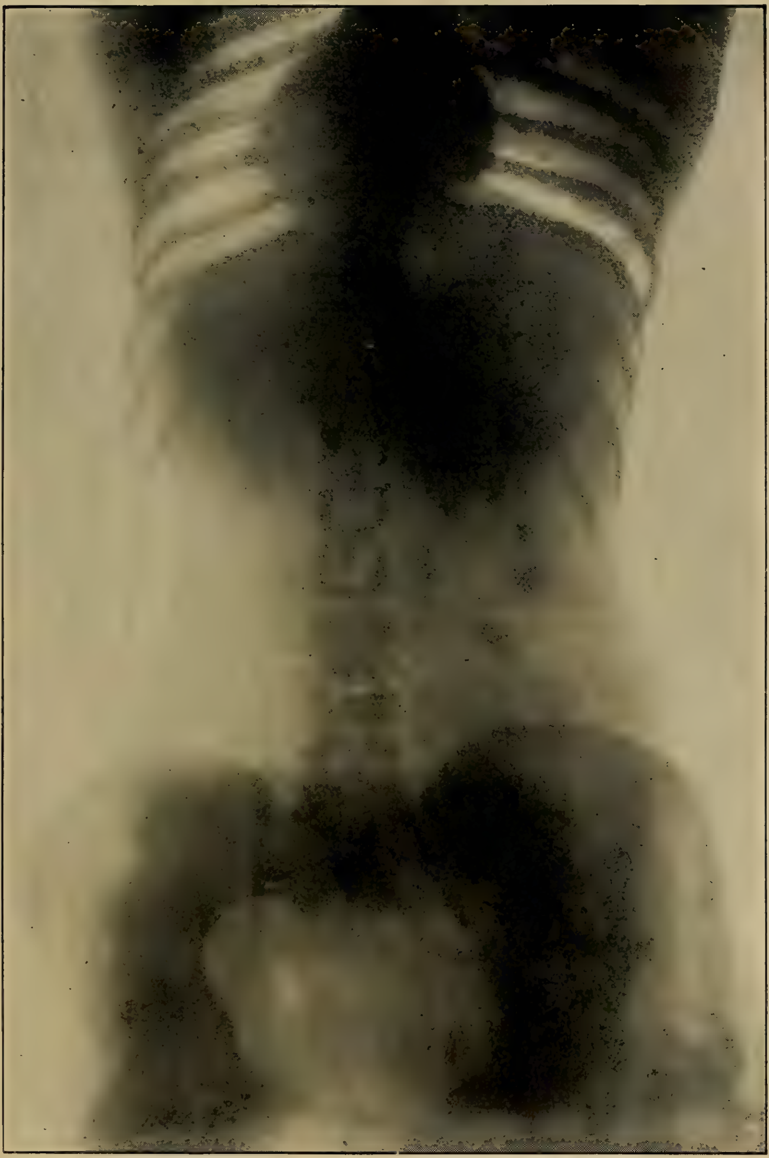


PLATE 121.—Renal Calculus (Walsham). Case of woman age thirty-nine. The diagnosis lay between renal calculus and tuberculous kidney. The X-rays cleared up the doubt. The negative showed that at least three stones were in the kidney, and the operation revealed a large number, varying in size from a large bean to a pin-head. They were composed partly of calcium oxalate and partly of phosphates. Good recovery. Both these radiographs of renal calculi were made with a twelve-inch coil and medium tube, with four minutes exposure. No special precautions with regard to holding the breath were taken in either case. The radiographs of the calculi after removal were made with the same coil and a few seconds exposure. (Rebman, Ltd.)

PLATE 122.—Life-size radiograph of the preceding renal calculus after removal from the patient. (Rebman, Ltd.)

PLATE 123.—Renal Calculus (Walsham). Case of a woman age thirty-three. Weight of stone on removal was $1\frac{7}{12}$ ounces, composed partly of calcium oxalate, partly phosphatic, the latter predominating. Recovery. The effect of reducing the radiograph to book size is well shown by the next picture of the calculus after removal. The shadow presents the appearance of two stones, but it proved to be a single calculus filling nearly the whole pelvis of the right kidney. (Rebman, Ltd.)

PLATE 124.—Life-size radiograph of the preceding renal calculus after removal from the body. (Rebman, Ltd.)

tion of soft and flexible metallic sounds into the ureters and kidneys for the purpose of securing accessory shadows as aids to diagnosis. On October 24, 1901, Dr. Schmidt wrote the author that since his paper before the American Medical Association they had had additional cases in which the method had been of great service. The lines of the metallic sounds stand out beautifully in the negatives, and show the course and situation of the ureters and the contour and size of the pelvis of the kidney.

"We use for sounds for this purpose lead-wire of different sizes and flexibility. We melt one end into a small ball. Lead-wire has sufficient tensile strength to stand manipulation without breaking, and, on the other hand, is so soft and pliable that injury to the tissues of the ureters and kidney is impossible even when there is dislocation of the ureter and a maximum of pressure is used. We use a cystoscope patterned after the instrument of Brenner and Casper. The diagnostic possibilities of this method are the following:

"1. The absolutely exact position of the course of the ureters.

"2. The exact localization of any obstruction in the ureter.

"3. The exact topographical localization of the pelvis of the kidney.

"4. The solution of a difficult differential diagnosis between biliary and renal calculi.

"5. Knowledge of the size of the pelvis of the kidney.

"6. The nature and meaning of any obstruction in the ureter.

"That these differential diagnostic possibilities are important and the command of them often welcome needs no emphasis. It is clear that the precise location of, for instance, an obstruction (an impacted calculus) in a ureter is of the greatest importance, for upon this point depends the accuracy and direction of the incision. The difficulties surrounding a differential diagnosis when a greatly distended gall-bladder, a floating kidney, or even a dilated kidney is encountered are well known. The uncertainty is lessened if in a case of this kind a metallic sound strikes directly upon a renal or uretal calculus and is radiographed *in situ*. Furthermore, the pliable lead-wire pushed to the limit of obstruction without danger will then roll up and outline the contour and shadow the size of the pelvis of the kidney in a renal case."

An experiment was first made on a cadaver. The lead sound was introduced with strong pressure and pushed forward as far as possible. Owing to the resistance of dead tissues it bent in every direction, finally doubling on itself and forming a loop in the pelvis of the kidney. After experimental radiographs an autopsy showed that no injury of any kind had been done the tissues by pressure *on* the soft lead. Three radiographs showing sounds *in situ* in bladder, ureter, and kidney were presented.

The following on renal calculus contains useful information:

"The radiograph exhibited shows a calculus in the right kidney, three-fourths of an inch in diameter, in a female child aged three and one-half years. The apparatus used was three twelve-inch spark induction coils connected in series and capable of giving a thirty-inch discharge of large volume, the secondaries being wound with No. 32 wire. The 110-volt direct current was used, regulated by a rheostat to the capacity of the tube. About eighteen amperes was let into the primary coil circuit. The tube was a General Electric funnel-focus tube with vacuum regulator, and the resistance backed up a parallel spark two inches long. The series spark-gap was one and one-half inches. More current was used than the tube would take continuously without melting the anode, and when it became too hot the current was cut off for a few seconds by means of an adjustable shunt spark-gap which regulated the current through the tube.

"The patient was anæsthetized and placed on her back with the tube *over the median line, level with the iliac crests.* The child would not keep still without the anæsthetic. A double-coated *X-ray* plate was used and developed with the metol-hydrochinon formula. Time of exposure was seven minutes, with the tube twenty inches from the plate. Thickness of the body on a line with the calculus was five and one-half inches. A second case was an adult, male, aged thirty-six. Calculus in right kidney. Postured on back; tube over kidney; distance, twenty-six inches; exposure, eleven minutes; body, twelve and one-fourth inches thick. Used double-coated X-ray plate.

"From reports of cases the general idea of locating a calculus seems to be to use a tube of as great penetrating power as possible, make a short exposure, varying from one to four minutes, and obtain a really under-exposed negative. It is assumed that a longer exposure will penetrate the calculus to an extent that will reduce its outline on the plate or obliterate it. I have tried all lengths of exposure, from a few seconds up to twenty minutes, and my most uniform results have been secured as follows:

"Use a tube which will take a large current and give off a large quantity of X-rays. Adjust it to just enough penetration to produce a normal plate for the given thickness (adult) in from ten to thirteen minutes, according to the thickness. In developing the plate aim at securing as much detail as possible." (SCOTT.)

Biliary Calculi.—In the living subject with early vacuum tubes and technics only such calculi could be radiographed as consisted of a firm and hard layer like the oxalates, while the more permeable urates cast an indistinct shadow, and the transparent phosphates scarcely appeared at all. The chemic composition of biliary calculi is far more complex than that of calculi in the urinary tract. All the different types have been experimentally radiographed on a plate outside the body, and also through the body of a patient to ascertain their difference in translucency, but the difficulty of shadowing them on a plate in living *situ* is not solely that of deficient density but of obscuration by respiratory movements. When technic controlled these movements success followed.

The common biliary calculi of the most frequent type is so permeable as to cast only a slight shade when small and single, but when larger and multiple the shadow is proportionately more dense. The mixed bilirubin calculi which contain traces of iron and copper, and pure bilirubin-calcium calculi, are found to be the most opaque, and hence yield the most distinct shadow in the radiograph. Pure cholesterin and stratified cholesterin calculi are slightly more opaque than the common biliary type. When gall-stones are discovered too large to pass the common duct medical treatment can presumably be only palliative, and operative interference may be deemed indicated. When medical treatment is tentatively undertaken in such a case a subsequent radiograph may detect whether or not calculi have passed on into the duodenum. In regard to technics Beck has the following:

" A fine tube is a *sine qua non.* The more translucent the calculus the shorter must be the exposure. Pure cholesterin needs a shorter exposure than a calculus containing lime, but the trouble is that we do not know the chemic composition of the suspected stones in advance. We therefore do not know what length of exposure-time will be necessary, but we can partly overcome this difficulty by making a minimum and a maximum exposure at the same time. If the short exposure reveals a calculus while the long exposure is negative, then the probability is that a cholesterin formation is present. Even a poor negative, if it shows but the faint outlines of elliptic and faceted bodies in the region of the gall-bladder, is positive evidence. Sometimes the film shows nothing but the calculi. The plate must always be carefully studied, because the inexperienced eye will often not recognize calculi which are obvious to the trained eye at a glance.

" In skiagraphing a gall-bladder have the patient lie on his abdomen with three pillows under the clavicles, for this elevation permits the protrusion of the gall-bladder and brings the calculi nearer to the film—an important feature. Also place a thick pillow under the symphysis pubes to arch the body. The nearness of the gall-bladder to the plate is also increased by turning the body slightly to the right and raising the left side.

" Another point of importance is that the axis of the rays should not be directly vertical over the gall-bladder, but should penetrate from the side, to avoid the thick and denser mass of the liver through its full diameter. Make the rays bear an angle of about seventy degrees with the plate, and the tube should be as near the abdomen as possible. When a protrusion, palpable in the region of the gall-bladder, indicates that it projects from the liver, direct vertical position of the rays is to be preferred. In the case of oblique exposure the slant of the rays will make the calculi appear larger than their actual size."

In his first success Beck used four superimposed plates at the same time. The top plate directly under the gall-bladder showed the outlines of the liver well, while in the last plate it appeared but faintly, but on this plate the calculi were clearly represented. The next exposure was made with a high tube on a single plate; time, ten minutes. After it was found how long it took this tube to show the liver and pelvic bones a second plate was exposed for six minutes. This negative showed the denser tissues less clearly, but the calculi were more distinct. An exposure of seven, one of eight, and one of nine minutes, were experimentally made, all showing that the *longer* the exposure the clearer were the denser tissue and the *fainter* were the calculi. It thus became evident that one exposure was not sufficient to determine the length of time required by a given tube for each gall-stone type. Tests should therefore be made by first making a trial short and a trial long exposure in a case of suspected cholelithiasis, say, one of four minutes and one of ten. By comparing the results of these test-exposures the proper time for a final exposure can be estimated.

"By employing this method not only the size, shape, and diameter of the gall-stones may be determined, but they can also be localized. It can also be shown whether there are calculi in the liver or the common duct besides those shown in the gall-bladder. Formerly it was only after extensive exposure by laparotomy that such diagnosis could be made with any degree of certainty. Exploratory laparotomy for suspected cholelithiasis will hardly be deemed necessary any more. The statement that the chemical composition of the calculi will have much to do with successful definition on the plate has been found to be correct to some extent only. Common calculi of the most penetrable type no larger than the head of a pin have been detected. Even calculi in the hepatic ducts have been shown. The bowels should be thoroughly evacuated before attempting the radiograph."

Moulin, in the London *Lancet*, early in 1899, wrote as follows of radiography of renal and biliary calculi:

"As regards renal calculi, the condition of the patient and the composition of the stone both affect the result. If the patient is thin, and the calculus of oxalate of lime, positive results can usually be obtained. Phosphatic calculi are harder to detect, and those of uric acid or urates still more so. If the patient is corpulent and muscular, success is less certain. *In difficult cases such as these, every endeavor must be made to reduce the thickness of the tissues by purgatives and enemata.* The position of the patient is important. The erect position fixes the object better, but crowds the liver down in front and increases the antero-

PLATE 125.—Radiograph of Renal Calculi. The arrows point to the shadows of two phosphatic stones which were removed by operation and the negatives confirmed. These soft calculi are here clearly shown, although prior to 1901 many claimed that they could not be defined by the rays.

PLATE 126.—A stone in the right kidney. Done by Davidson with patient on back. Anode 13 inches from plate. Exposure 2 minutes. Ten-inch coil and mechanical interrupter. In the last of three cases examined soon after by the same operator and using a Wehnelt interrupter the renal calculus could "be distinctly seen on the screen." It was also radiographed. Note the division of the negative into quadrants by the cross-wires by method illustrated in a previous chapter.

PLATE 127.—Arrow points to large stone in left kidney which was removed by operation, verifying the radiograph.

PLATE 128.—Ureteral Calculi. First radiographed with tube placed for suspected stone in kidney with no result. Tube was then focussed on course of ureter, and the two calculi here shown were discovered. Removed by operation, which verified the findings of this negative. The arrows point to the two shadows.

posterior diameter of the body. *Have the patient recumbent with the back well arched.* Make examinations both from the front and from behind, as it cannot be told in advance which will yield the best results with some patients. To prevent movement of the calculus from respiration, direct the patient to hold his breath as long as possible in forced expiration, to raise the liver. Then cut out the tube and allow him to breathe until he has recovered himself, and resume the exposure for a second period of arrested respiration, with the thorax the same as before. Repeat this as often as necessary till the radiograph is completed. The tube is only switched on during the period of apnœa when the thorax is at rest, and the kidneys and the calculi are presumably occupying the same position relatively to the light. As regards biliary calculi, they are still more difficult, owing to their very low densities. The difficulty is greatest when information is most wanted, that is, when the calculus is not in the gall-bladder but in the ducts, and when the patient is stout and the abdomen firm."

Technic for Renal Calculi.—Previous to the exposure fast the patient and thoroughly empty the bowels. Remove all clothing from the region to be radiographed. Have the patient make forced expiration and tightly secure a thin muslin binder around the abdomen to restrict movement of viscera during respiration. This is important. Place the author's Position-Finder on the table and centre a high-efficiency tube at twenty inches for an 11 × 14 plate. Remove the rod and all is ready for posing the patient. There are now three objectives which govern the placing of patient and tube. The purpose of the picture decides the technic, and an advance choice must be made.

1. Exposure of both kidneys at once for suspected presence of calculi.—Bring in the plate and place it on the centred base under the tube. Lay the patient on the plate so that the third lumbar vertebra is on the centre of the film. Prop the patient with suitable towels so as to secure comfort and to make the closest possible contact of the part with the film. The focus of the anode being over the centre of the spine the diverging rays will carry the shadows of the kidneys well out from the bones on each side, and equally image both sides with neither in the perpendicular axis. This is immaterial in simple detection.

2. Exposure of one kidney only.—Mark the region of the selected kidney on the skin, and then simply lay the patient on the plate with the marked area over the centre of the film. The kidney will then be in the vertical axis of the rays, and there will be no divergence to consider. The shadow of the single kidney will fall directly below it to the plate. The patient may be placed either on the back or abdomen, and it is often best to make an exposure in each position to ascertain which gives the best result in the given case. A thin person will suit

the frontal posture best. An obese person will suit the dorsal decubitus best, as a rule. Use the Distortion Landmark as a guide to approximate localization.

3. To localize a calculus after preliminary detection.—Having found the shadow of a calculus in the image of one side of the body and desiring to exactly localize it in the kidney or ureter, mark on the skin its estimated situation as indicated by the first radiograph. Place the patient so that this mark is on the centre of the film and the focus of the tube vertically over it. Select and employ the preferred method of ascertaining the seat of the calculus from our chapter on Localization.

When all is ready for any one of the above exposures have the patient keep absolutely still and breathe as little as possible while the current is switched into circuit. With the fluoroscope observe the action of the tube and time the exposure as taught.

A fine photographic screen of tungstate of calcium may be applied to the film of the negative to shorten the exposure. Or, the plate may be sandwiched between two such screens, as is done by leading operators in Europe to some extent. A diaphragm may be used to cut out all but the direct rays.

Results.—The shadows of the last rib and the transverse process of the first lumbar vertebra are guides to look for the calculi in the developed negative. Develop slowly with weak solution, watching these shadows and avoid fading them by too rapid or over-development. It is almost true to say that here (aiming at retaining on the plate shadows of tissues less opaque than the least opaque calculi) *development* is more vital than exact exposure-time. With experience the art grows.

If nothing is seen on the plate at the end of development that may be considered evidence of a calculus *intensify* the negative and let it dry. Then place it in the examining-cradle, as elsewhere described, and with the borders dark and with regulated transmitted light, study the shadows at various distances up to six feet. If this discloses any specks which may be suspicious repeat the exposure with such modifications as appear indicated by the result of the first attempt. When the shadow of the calculus is seen on the plate the diagnosis is positive. When several plates give clear definition of the field without suspicion of stone, and especially if outline of the kidney is secured, the diagnosis is negative.

Remarks.—It has been surmised that many of the failures of the past to radiograph renal calculi when they were actually present were due to making more or less long exposures with the patient permitted

PLATE 129.—Radiographic exposure for Vesical Calculus. Patient on canvas stretcher with region exposed free from clothing.

PLATE 130.—Radiograph of Vesical Calculi showing two stones in the bladder, both of which were removed by operation which verified the negative. The arrows point to the calculi.

PLATE 131.—Stone in the Bladder. The electrotype shows scarcely any of the fine detail of the original negative.

It is, however, inserted here to point out that no practitioner should form his opinion of radiography from the ordinary blotches of well-nigh meaningless ink that figure as copies of superb negatives in the hasty presswork and coarse paper of ordinary medical journals. They bear little relation to real radiography.

PLATE 132.—Vesical Calculus by Mackensie Davidson. This radiograph was made prior to July, 1897, and the technic was as follows: The patient was placed face downward on a rapid film wrapped in two folds of black sateen cloth under the pelvis. The posture was such that the stone would fall to the front wall of the bladder and thus come nearest the film. The tube was so placed that the rays should pass obl quely through the pelvis and avoid the intervention of the bones. The result shows the shadow of the calculus, which was estimated by the operator to measure 3.4 centimetres diameter. The actual measure was 3.1. The exact distance of tube and time of exposure are not stated. The loss of fine detail in the half-tone greatly lessens the value of the illustration. (Rebman, Ltd.)

to maintain ordinary respiration. The repeated movements of the ribs, the soft parts in general, and, possibly, to some extent of the kidneys themselves, would blur out the faint opacity of a small substance of slight density hidden deeply from the plate and hard to outline. The more nearly fixed the stone during exposure the less difficult to image its margins. In addition to the binder the patient can aid fixation by letting out his breath and holding his muscles still as long as possible. Stop the tube when he must relieve the lungs, and work it *only while the parts are under forced expiration.* The shortest practicable exposure-times are best for clear definition.

Technic for Vesical Calculus.—In exposing a patient for a radiograph in a case of known or suspected stone in the bladder not only should the intestinal tract be flushed out, but at the last moment the bladder itself should be evacuated, as water casts a shadow with X-rays.

Abdominal Position.—Place the patient face downward with the vesical region on the photographic plate, tilt the table so that the stone if present will gravitate to the front wall of the bladder nearest the film, place the tube so that the axis of the rays will pass obliquely through the soft parts of the pelvis and avoid the heavy bones. Make a short exposure with the tube-wall about eight inches from the tissues. Always remove clothing from the pelvic parts.

Dorsal Position.—Place the patient on the plate so that with pillows under the back and the knees drawn up the outlet of the pelvis will be in the nearest relation to the film. Place the tube over the abdomen above the umbilicus so that the axis of the rays will fall through the pelvis perpendicularly to the plane of the outlet. As no bones are to be penetrated make a short exposure. The distance of the tube from plate may be suited to the thickness of the parts. Simply have about eight inches between the tube-wall and the tissues.

Refer to section on photographic screens for shortening exposure-time. In these cases richness of photo-chemical action on the film is more important than high penetration or the fine details desired in certain negatives of bones, and the slight graining of the tungstate is not a drawback. Those who secure a really fine photographic screen to-day will be surprised to note how very slightly it marbles the negative.

Although the detection of vesical calculi is generally very easy by ordinary methods, yet the author had a case in which the ablest surgeon in a large city was not successful till repeated examinations were made and the patient so debilitated that when the final attempt detected the stone and an operation was done he died in two weeks. There are also special applications of the X-rays that are valuable, such as the detection of encysted and multiple calculi, the determination of the presence of calculus in conjunction with an enlarged prostate, and in cases where there is mechanical difficulty in the way of employing the usual sound. The fact that a mechanical examination is not painless and is no more certain than a painless, harmless, speedy, and very accurate X-ray exposure indicates the growing value of the latter. Further perfection in technic will no doubt make it the only method in vesical cases. The number of successful radiographs of vesical calculi made in 1901 was very large and demonstrated the practical utility of X-rays in this field.

CHAPTER XXXIII

DENTAL SKIAGRAPHY

USES. TECHNICS IN FULL. LECTURE STUDIES.

THE first section of this chapter has been prepared especially for this System of Instruction, by C. Edmund Kells, Jr., D.D.S., of New Orleans, La., to whose painstaking care in presenting the subject the author is much indebted.

It being impossible to insert each Instruction Plate in the place in the text designed by the author the reader will refer to the series in proper order upon separate pages in the section. No other treatise has given dentists such plain directions for radiography as will be found in this presentation by Dr. Kells.

"Immediately upon the announcement of his discovery by Professor Roentgen the dental profession recognized the value of the new art of skiagraphy as applicable to their own and at once commenced its study. Up to that time any abnormal conditions existing within the alveolar processes were diagnosed entirely by the judgment and experience of the dentist, which naturally were not infallible, and a difference of opinion relative to a given case could easily be found between men of equal standing. But with the aid of the X-rays all such cases may be removed from the realm of doubt into one of exact knowledge, by which the diagnosis and prognosis are rendered positive. While some operators have constructed small fluoroscopes for use within the mouth, and others have contrived modified forms of Crookes tubes for projecting the rays from within outward, we may safely assume that the chief practicable application of the Roentgen ray to dentistry is through the art of skiagraphy, and its uses are as follows:

"1. In Orthodontia, revealing the position of un-erupted teeth.

"2. In cases of the non-eruption of the full complement of teeth, their absence from, or presence within, the alveolus may be demonstrated.

"3. By obtaining correct outlines of the root or roots of impacted third molars their extraction is rendered much less difficult, and frequently such teeth that would otherwise most certainly have been broken are now successfully removed through such information obtained.

"4. Teeth with abnormally shaped crowns are frequently unrecognizable, and whether they are deciduous or permanent can only be ascertained by the shape and number of their roots. Skiagraphy, and it alone, renders the diagnosing of such cases possible.

"5. The extent of an abscess may frequently be clearly exhibited by a skiagraph, and its treatment rendered more intelligent in consequence.

"6. The conditions which obtain about the roots of implanted and replanted teeth may be studied, which is most interesting and instructive.

"7. Whether or not an instrument unfortunately broken off in the root-canal protrudes beyond the apex may frequently be determined by a skiagraph; which knowledge is of the utmost value.

"8. Whether or not the root of a malformed tooth is of sufficient size as to warrant a crown being attached is ascertainable, and thus such an operation not performed unless its success is assured.

"9. Fragment of roots lying completely within their bony sockets, the size, shape, and position, or even existence, of which are not otherwise ascertainable, are plainly shown upon the skiagraph, and thus their removal rendered much more feasible.

"10. For discovering supernumerary teeth.

"11. Not infrequently a person will receive a fall, or blow, by which the front teeth are loosened in their sockets, or their roots fractured, and which of these has occurred is sometimes most difficult to decide, as manipulation of the parts is most undesirable. In such a case a skiagraph may set one's mind at rest, and dictate the treatment necessary.

"12. The apical foramen of a root may be unduly large, or a drill may have been allowed to penetrate too far, in either case it is rendered difficult to close this opening without allowing the filling material to protrude too far; or, perchance the canal may not be filled to its fullest length, both of which circumstances would prove fatal to the success of the operation.

"In such cases we may proceed as follows: After the preparation is completed *a lead post as large as possible is carefully inserted to the supposed proper depth*—that is just to the end of the root. This is cut off at the opening into the tooth or root-canal, whichever is most desirable, and sealed in place with temporary stopping. *A skiagraph is then taken* by which it will be clearly seen whether the post protrudes beyond the apex, is not long enough, or is just right, and the continuation of the operation proceeds accordingly. Thus having noted that the new art of skiagraphy does much for the advancement of the science of dentistry, we will proceed with the technique of the work, limiting ourselves entirely to the methods used in practice by the writer.

"It should, however, be borne in mind that in dental work we do not get the contrast between tooth and the bone surrounding it that may be obtained in other parts of the body where bone and flesh are in opposition. In many cases distinct and clear pictures of the roots of teeth may be obtained, but in others (owing to the conditions obtaining) only the faintest outlines may be seen, and while these are all that may be necessary for diagnostic purposes they will not bear reproduction for satisfactory illustrations. Success in skiagraphy is entirely a matter of experience and attention to details; it being largely dependent upon the art of photography. If one is not more or less of an amateur photographer and familiar with the processes of developing and fixing a plate, and capable of printing a picture, it would be best for the beginner to *see* this done in all its stages—*not once, but several times—by an expert in that line.*

"In the question of the choice of a generator of X-rays I was guided by the fact that the alternating current was available, consequently I selected a 'Tesla Coil.' During the five years since its installation it has required but a minimum of care, and has always responded to the closing of the switch. The circuit breaker is simple and efficient, and water rheostats are used because of their capacity for minute graduations of the current.

"It is possible that tubes used upon a Tesla Coil are more liable to puncture than when used upon any other form of generating apparatus. Be that as it may, I was annoyed greatly by this trouble, obtaining no assistance upon the subject from the manufacturers, who appeared to be entirely at sea in the matter. Upon a close study of the workings of the apparatus I finally concluded that a certain pole of the coil, strange as it may seem, appeared to have a higher potential than the other, or at any rate the phenomena at that pole were in marked contrast to those to be observed at the other. To this 'positive' pole, as we call it, the terminal of the tube *away* from its stem is connected, and the connection nearest to the stem, of course, to the other pole.

"Next a wire is grounded and so secured as to have its free end poised near the stem connector of the tube and more or less adjustable, so that the distance between the end of the wire and the tube terminal may be regulated as needed. Under ordinary conditions when running there is always more or less sparking between the tube terminal and the stem, and I concluded this was the cause of the puncturing. But under these modified conditions the current leakage is diverted to the grounded wire and so avoids the risk to the tube.

"Whether this theory is correct or not I cannot say, but I do know that I have had no puncturing of tubes since I devised this feature.

"Fig. 1 shows the corner of my laboratory in which the work is done. The Tesla Coils contained in their oaken boxes are shown upon the left, with the circuit breaker in a box against the wall upon their right. A generous-sized fluoroscope (the one shown is 10×12) is better for general purposes.

"An old type-writer table at hand was first used to hold the tube-stand, and has proven so satisfactory that it has never been replaced by a more modern contrivance. The tube-stand has two clamp arms, the one for the tube, the other for the 'Tesla screen.' An ordinary LeClanche battery-jar containing water slightly acidulated with sulphuric acid, and two electric-light carbons capable of vertical adjustment, form the very satisfactory regulator for the circuit breaker; and a Western Union jar fitted with one copper and one adjustable carbon electrode, with the same solution, governs the current supplied to the coil. In the shelf above large holes are bored which are fitted with cork cylinders, affording a safe method of holding the tubes out of harm's way. An ordinary piano-stool, the seat of which may be raised or lowered, and a photographer's head-rest, I have found the best means of getting patients into comfortable and satisfactory positions, and holding them therein. The tubes used are the best that can be procured. The next subject for consideration is the sensitized surface upon which the skiagraph is to be recorded.

"For this purpose the ordinary photographer's glass-plates, celluloid-films, and bromide papers, to be found among photographer's supplies, are available; but, *better than these, for dental purposes, are some celluloid films coated with a specially prepared emulsion particually well adapted to the action of the X-ray.* While glass-plates prove satisfactory upon flat surfaces, the flexibility of the celluloid allows its adaptation to the curvature of the mouth, consequently the latter is preferable. Again the glass is cut with more or less difficulty, which is an objection not found with the celluloid. The bromide paper possesses the advantage of giving the finished picture in one operation, but also the objection that numerous 'prints' cannot be made from it, as from the transparent skiagraph.

"In ordinary photographic processes the production upon the gelatine film is a 'negative' from which 'positive' prints are obtained, while in skiagraphy the reverse obtains; the X-ray film is a *positive*, consequently prints therefrom are negatives. If for any reason positive pictures are desired they may be obtained by placing the skiagraph in a printing-frame in contact with a *plate*, and exposing this to the light for the required length of time to produce a good negative. This is then developed, fixed, etc., and, when completed, prints obtained therefrom are positives. In Fig. 2 we have above an ordinary picture printed from a positive skiagraph while below is shown a 'positive' print made in the manner described.

"Naturally the sensitized film must be protected from both ordinary light and *moisture* during its exposure in the mouth, for which purpose it must be enveloped in some material which must of itself be transparent to the X-ray, and yet possessing these other requisites. In many cases an envelope may be made of black paper (in which the films or plates come wrapped) with its edges pasted down. If there is danger of moisture (in lower cases, for instance) this may be again wrapped in water-proof paper or gutta-percha tissue, all of

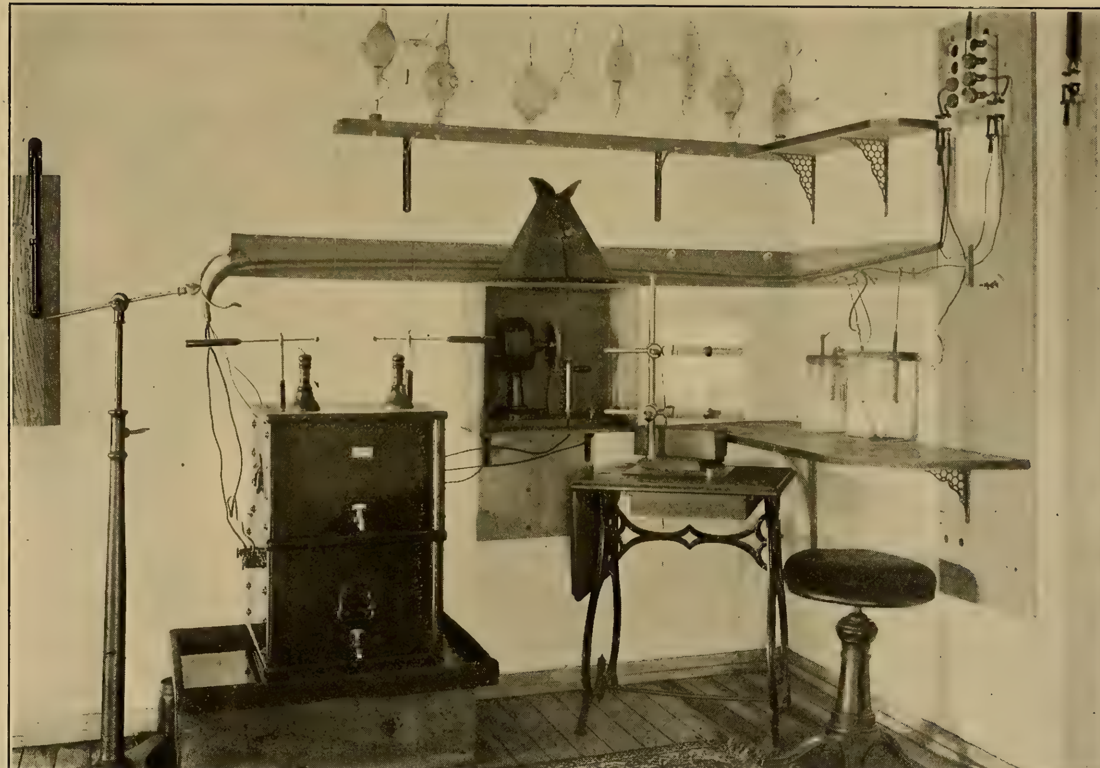
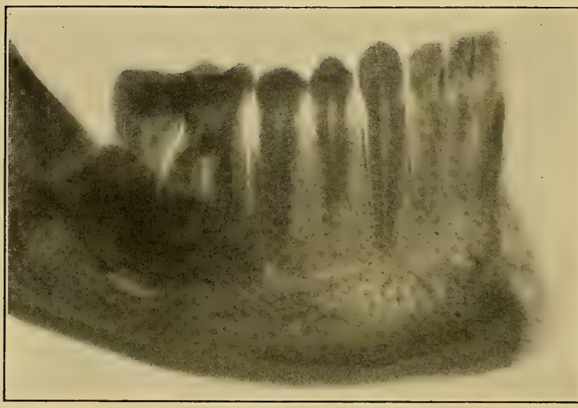


Plate 133.—Plate 1 of Dental Series, showing corner of the author's Laboratory in which his X-ray work is done.



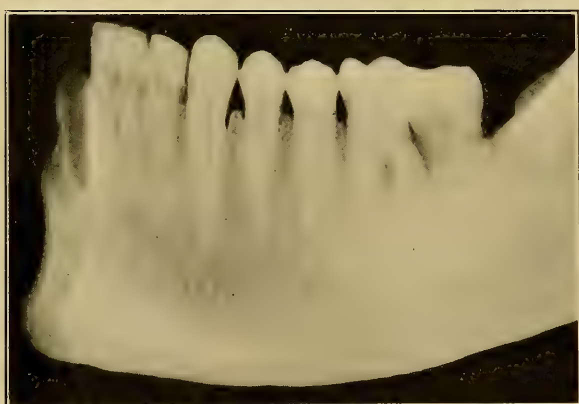
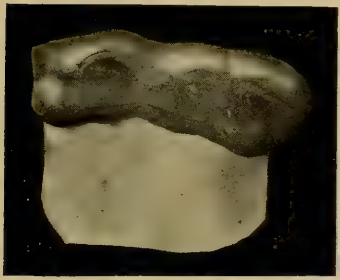
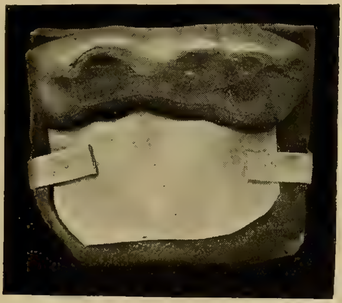


PLATE 134.—(2) The upper plate shows an ordinary picture printed from a positive skiagraph, while the lower picture shows a "positive" print made in the manner described in the text for Figure 2.

(3) Model of the upper teeth of a youth at 14, in which a cuspid is missing and long overdue. In all probability it is dormant within the alveolus, and requires a radiograph for diagnosis as per description in text.





At the left in this plate is seen the film-holder made for radiographing the above case. At the right is shown the holder with the film attached and held securely by the two side clamps. (Figs. 4 and 5 of the text.)

This plate (Fig. 6 of the text) shows the picture obtained and clearly outlines the crown of the missing cuspid lying well toward the median line of the root of the lateral. See text for treatment.

Plate 135.

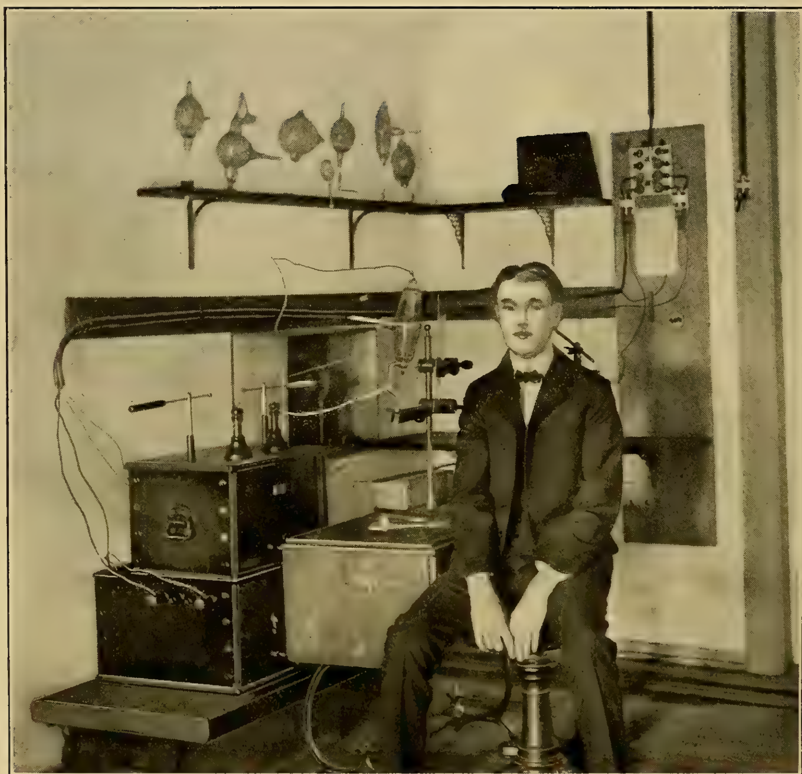


PLATE 136.—This plate (Fig. 7 of the text) shows the position of the patient with the film in his mouth in readiness for the exposure which made the above radiograph. The grounded aluminum screen shows faintly between his face and the tube. In altering the face of the subject to disguise the identity the reproduction has unfortunately shifted the correct pose of the head with relation to the tube. The picture will, however, give a sufficient idea of the work for others to follow. Some pose the patient in the regular dental chair, which affords a steady head-rest with an easy semi-recumbent position. A variety of tubes is seen in the rack above the apparatus. The various wire connections are shown with instructive distinctness. With the aid of the text of this chapter any dentist should be able to succeed in radiography.

which are practically transparent to the X-ray. A very convenient covering, however, and the one which proves satisfactory in most cases, is the ordinary black dental rubber, which is at once both light- and moisture-proof, and is at the same time most easily handled. Of course the rubber which is furnished in the thinnest sheets is preferable. Folding this over the film and pinching the edges together seals it perfectly. In this case the gelatine surface must be protected from contact with the rubber by a piece of tissue-paper, or what to my mind is better, as will be explained later, two films may be used put face to face.

"We must bear in mind that in order to procure a skiagraph with perfect outlines the patient and the sensitized film must be held immovable during the time of the exposure. In many cases the patient or an assistant may hold the prepared film in place in the mouth, but in some special cases this may not prove satisfactory, when *a film-holder should be made as follows:* Over the crowns of the teeth to be skiagraphed is moulded a thin layer of modelling compound, to which is attached a piece of aluminum plate about twenty-eight gauge, and of such size and shape as to cover the region to be skiagraphed. The edge attached to the compound being slit every one-eighth of an inch or so, and the little pieces bent so as to secure a better hold in the compound. The aluminum is bent to conform to the mouth and lay as snugly against the mucous membrane as possible. To this is attached the prepared film by small U-shaped clamps of aluminum about one-eighth of an inch wide and long enough to hold the two together, when pinched down with plyers, as will be shown later.

"When this is placed in the mouth the patient should close upon it with the opposite teeth, thus holding it securely in position. At the same time this very act of closing his mouth places him in a very comfortable position, allowing him to swallow, and, in case of necessity, he can remain immovable and comparatively comfortable for a considerable length of time.

"Having proceeded thus far it will probably simplify matters for us *to take a case in practice and carry it through from beginning to end.* In Fig. 3 is shown the model of the upper teeth of a young man of fourteen in which it is seen that a cuspid is missing, and long since overdue. In all probabilities the tooth is lying dormant within the alveolus, consequently we will proceed to skiagraph the case that it can be treated more intelligently. Fig. 4 shows the film-holder made for the case. (See Plate No. 135.)

"In Fig. 5 is shown the holder with film attached, held securely by the little clamp at either end; while in Fig. 6 is shown the picture obtained, clearly outlining the crown of the missing cuspid lying well toward the median line of the root of the lateral. The treatment therefore indicated is to push the first bicuspid back against the second, rotate and bring the lateral into its proper position in the arch, and drill out fully and deeply the bony tissue to the labial or rather buccal side of the cuspid, which will naturally fall into the space thus made, and erupt in the proper or very nearly the proper position.

"In Fig. 7 is shown the patient in position, with the film attached to the holder in the mouth and all in readiness for the exposure.

"Between his face and the tube is a 'Tesla screen,' a thin plate of aluminum 'grounded' to the gas-pipe by a fire wire. Now I do not believe it possible, from the history of X-ray burns which I have read, and from my own experience, for any such to occur during the short exposure to which we submit our patients, but the screen is used for two reasons—the one upon 'general principles,' which should always cause one to take every precaution for his patient's good, and the second, to protect his face from flying fragments if perchance a tube were to break, of which I have read but never experienced. Thus the screen does double duty in protecting both operator and patient.

"In 'posing' the patient it must be borne in mind that the best results can be obtained only when the object to be skiagraphed is at right angles to the rays from the tube, and the film parallel to, and as near, this object as possible. This renders such results obtainable only upon the posterior teeth when the vault is high in upper cases, and in lower cases when the floor of the mouth is deep, and the processes straight. All other cases, and the anterior teeth where the film must be curved, give only distorted pictures, which, however, are frequently all that are needed for diagnosis.

"The exposure completed (which is best accomplished in a darkened room that the behavior of the tube may be followed), the length of which in each case depends upon the efficiency of the tube at the moment of use, and the thickness of the bone to be penetrated, varying from twenty seconds to one and one-half minutes, we transfer our scene of operations to the dark-room where the 'development' of the film is proceeded with. Successful work of this character, as before stated, depends entirely upon the experience and skill of the operator; assuming, of course, that his apparatus is sufficiently efficient. Nor do I believe that any one can learn any but the rudiments from reading—one should have it demonstrated if possible, and then practice until proficiency is reached.

"In order to learn what details of technic produce good results, and what produce failures, a careful record of each case should be noted, from which comparisons can be made.

"It being desirable to keep our skiagraphs systematically and conveniently, what better method of preservation of both it and its records could there be than an envelope specially prepared for this purpose? In Fig. 8 is shown a plain manila envelope printed as desired, which we date and number when case presents, and as soon as the exposure is over we enter the necessary notes. (Plate 137.)

"With each class of sensitized films, for there are many with varying qualities, full directions for developing accompany them;

the only choice we should have in the matter, other things being equal, would be the selection of a formula that does not stain our fingers in preference to one that does, if both are given, which fortunately usually occurs. 'Pyro,' which appears to be the favorite with professionals, does stain very badly, consequently should hardly be used by the dentist, for it is almost impossible to use these solutions and keep the hands entirely free from them. Metol-hydrochinon, which is a favorite with many manufacturers for use by 'amateurs' has many advantages, does not stain, and is used almost exclusively in my work.

"I rarely take a *single* skiagraph for reasons which will be shown later, but *superimpose* two or more films upon each other, arranging them so that the gelatine surfaces are not in contact with the protecting envelope if it be of rubber. The plural films having been exposed, we now go into the dark-room, where our vessels and trays are conveniently arranged as shown in Fig. 9. I have found that an ordinary photographer's 'clip' is most convenient for handling these little films and prints, as by them they can be carried through their various processes from start to finish without any handling by one's fingers, and without touching their sensitized surfaces.

"One set of clips so plainly marked as to be recognizable in the dark-room should be used for developing only, after which the film is transferred to another clip by which it is carried through the other processes. In the dark-room two features are most important, the first, having a *perfectly safe* 'ruby' light, and second, absolute cleanliness of the vessels employed.

"Upon the left of the picture of my dark-room is shown *an ordinary saucer*, which I find most convenient for developing such small films as we use for dental purposes. This process is commenced preferably with some old solution that has been used before, and, consequently, weakened; or, if this is not at hand, fresh solution is used, diluted with one-fourth its volume of water. A sufficient quantity of this is poured into the saucer and the several films placed therein, *face downward*, the saucer being rocked while the process is watched. In a few moments they are *turned over*, and when somewhat darkened the developer is poured off and thrown away *and new* solution flowed on. One of the films is then caught up by an unimportant corner in a pair of clips and the process continued, the film being held before the light from time to time to see its progress. When it is considered fully developed it is thoroughly rinsed in the little jar of water next to the saucer by whisking it up and down a number of times, when it is caught by another clip, and by this one hung in the next jar, which contains the fixer. (See Plate No. 138.)

"We then go back to our other films, catch one of them by the first (developing) clip, keep it moving in the solution for a full minute, *slit one corner with scissors for a depth of one-eighth inch or so*, then rinse, transfer it to another clip, and hang it in the fixer. This process is repeated with the other films which are slit in turn 2, 3, or 4 times as may be necessary, and which will in all probability be considered ruined by over-development.

"Once the films have been whisked around in the fixer so as to be sure the solution touches every part of their surfaces, the light may be turned on. We now allow these to hang in the acid fixing bath, composed of the formula recommended by the makers of the films, from fifteen to twenty minutes to assure their preservation, and then transfer them to the washing jar, which is seen in the sink. This consists of an ordinary Western Union battery jar, with a notch about three-eighths of an inch wide and the same in depth, ground out of its upper edge. In this is hung a bent glass-tube, its inner end having a piece of rubber tubing attached, which reaches to the bottom of the jar. Upon the outer end another piece of tubing extends an inch or more only. The jar is first filled with water from the tap above, which starts the syphonic action through the bent tube, when the tap is almost closed, only allowing a very small stream to run. The films are thus most thoroughly washed, the heavier solution of the 'Hypo,' as it falls to the bottom of the jar, being carried off by the rubber tube. Most thorough fixing and washing is necessary in order to insure the permanency of the skiagraph. Thin films, such as are used in the Kodak, may be fixed in ten or fifteen minutes, and washed in one hour in such an apparatus, while the double- or triple-coated films, made specially for X-ray work, *require double this time* for each process.

"When the washing is completed the Kodak films are transferred to the jar upon the left, which contains the glycerine solution, in which they are hung for five minutes, after which they are hung upon the wire above to dry. The object of the glycerine is to prevent the films from curling while drying, which they otherwise would do. The flat heavy films do not need this precaution, but are taken out of the water and hung up to dry. During hot weather all solutions should be used ice cold to prevent the films from being spoiled by 'frilling,' and it is advisable to hang the films in a saturated solution of common alum in water for five minutes to harden them. They must also be washed in cold water or the change of temperature may cause 'reticulation' of their gelatine surfaces, which would also spoil them.

"The manufacturers of plates and films furnish instructions for 'intensifying' negatives, but I must admit that as far as skiagraphs are concerned I have never been able to succeed in improving them by this process. The drying of the films is a tedious process requiring hours unless they are hung in a strong wind, but it may be hastened as follows: After being washed the film is placed in *absolute alcohol* for about five minutes, taken out and *hung before an electric fan where it will dry out in a few moments.* Of course the smaller the skiagraph the quicker it will dry. Having carried our three or more duplicate skiagraphs through these various steps, and, finding them finished, we are able to recognize which were developed the longer, and which the shorter, time *by the number of slits made in them*, and the *probabilities* are that the one which was allowed to remain the longest time proves to be the best.

" *The point at which to stop the development is most perplexing to decide, and this method was devised to tide me over this difficulty, and I can but believe it has distinct advantages over the taking of the single skiagraph.* As soon as the skiagraph is put in the washing jar we turn to our recording envelope and complete the details as to the developer used, etc., and enter any explanatory notes that may be pertinent. The next step is to obtain the print or picture from the skiagraph, which is rendered comparatively easy by the introduction of the *developing papers* capable of being worked by artificial light.

" Having decided upon a brand known as ' Velox,' we prepare the formulas recommended for its use by its manufacturers, and proceed very much as we did with the original skiagraphic film. Under dim light (either day or artificial) we cut the paper to the desired size and place it over the film (the back of which has been wiped off so that it is perfectly clear) in the printing frame, being careful that the gelatine surface of the film is uppermost, and the sensitized surface of the paper, which is recognizable by the very slight curling of the paper toward it, is downward, and expose it to the light as per directions supplied. It should be noted that when two or more films are superimposed upon each other that those with the gelatine surface *away* from the part skiagraphed will show the picture reversed *unless printed backward*, which should be done.

" Sufficient developing solution is placed in a saucer, the paper caught up by one corner by the clip and immersed in cold water for a few seconds and then laid *face downward* in the solution, the paper being slid in edgewise that no air bubble will form upon the surface, and the saucer gently rocked. It is almost immediately reversed so that the development, which takes place at once, may be carefully watched, the paper being always kept well covered with the solution and the saucer gently rocked. As soon as it reaches the proper degree of clearness it is quickly plunged into the jar of clear water, whisked up and down a few times, and then hung in the fixing bath, being sure to change clips for the purpose. After it has been well fixed it is washed for an hour, as was the film, when it is ready for mounting.

" The card as shown in Fig 10 affords a convenient mount which, at the same time, contains all the information relative thereto that needs be known for an intelligent understanding of the case. These should be put in an album, and thus maintain at ready access a complete record of one's work. Very frequently a patient desires a print, in which case it would probably be better to mount it upon one of the small embossed cards intended for Kodak pictures.

" The following are a few details that should be firmly impressed upon one's mind:

" Do not expose the films to even the ruby light unnecessarily long.

"Do not allow the least particle of the fixing solution to get into the developer.

"It is best to make up the solutions needed from fresh chemicals, rather than to use the prepared 'tubes' sold in the market, and use distilled water.

"Clips that are used for handling the films in the fixer may be used for washing them, but for no other purpose. Those used for developing should be plainly marked.

"Glass vessels may be used indiscriminately for either solutions, but must be most thoroughly washed.

"The developing solution of Metol-Hydrochinon can be kept for weeks in small, say four-ounce well-stoppered bottles, filled right up to the corks. When it becomes discolored it should be discarded.

"The acid fixing bath will also keep for several months, but should be decanted when necessary. Finally, after continual usage it loses its strength, when it should be discarded.

"In order to test a film, or plate, to ascertain if it is still good (for they do not keep indefinitely) proceed as follows: Cut off a small piece, and, placing it in the developing solution, treat it as if it were an exposed plate. After allowing it to remain in the solution a few minutes rinse and fix. If it comes out of the fixing bath perfectly clear that is proof positive that it was good—if not clear, that it had deteriorated and should be discarded.

"If a film fades out after fixing it is an evidence of not having been allowed to remain in that solution a sufficient length of time. The rule should be to allow the film to remain in the fixing bath twice as long as it requires to clear the back of its whitish appearance.

"Sometimes one's printing paper (Velox) becomes spoiled. If there are any doubts about it, it may be tested in the same manner as the film.

"Referring now to the figures in our Instruction Plates we have an illustration of the use of the skiagraph as applied to Orthodontia which has already been given in Fig. 6. Fig. 11 represents a model of the lower teeth of an adult, in which one incisor is missing, and upon the right the skiagraph showing its absence from the alveolus. Class 2. Fig. 12 is a case of an impacted lower third molar, and the skiagraph of the same, by which its removal was rendered easy; besides which is shown the tooth itself after extraction. Class 3.

"In Fig. 13 a model of the lower jaw is shown, in which was placed in its original position, the third molar after its extraction, and which extraction was rendered comparatively easy by the skiagraph shown. Class 3. Fig. 14 represents the lower teeth of a miss of fourteen, in which is shown an abnormally shaped second bicuspid, and upon the right the skiagraph of the same. That it has a single root proves it to be the second bicuspid and not the retained temporary molar, which tooth would show bifurcated roots. Class 4.

"In Fig. 15 is shown a skiagraph of a lower incisor, around which it is seen that the alveolar process has been entirely destroyed by an abscess, besides which the apex of the root has been absorbed. Class 5. Fig. 16 shows a *second* molar which was extracted and replaced, and the accompanying skiagraph *taken one year later* shows the roots perfect, no absorption having occurred. Class 6.

"Fig. 17 shows indistinctly, on account of the flatness of the arch, the root of a first upper molar in which a broach has been broken off. Class 7. Fig. 18 represents the model of an adult showing a malformed left upper lateral, and the skiagraph which shows the root of sufficient length as to justify a crown. Class 8.

"Fig. 19 is a reproduction of a root which was *crowned* and *tubed* in order to share with its mate upon the opposite side of the arch in carrying a set of nine teeth, which it failed to do except for a short time. Had this been skiagraphed beforehand it is probable that it would not have been so taxed. This case comes under Class 8. In Fig. 20 upon the left is shown the remains of a third molar which had been '*extracted*' one year before, and which was entirely invisible, being covered by the gum, yet easily extracted by the aid of a skiagraph, after which it was placed in the model in its original position. Upon the right is a skiagraph of an invisible root of a lower bicuspid, which was readily removed. Class 9.

"Class 10. A very interesting case, the duplicate of which I have not seen recorded, came under my observation and is shown in Figures 21, 22, 23. The subject was a child of twelve, the model showing the left central unerupted, and no signs of it could be discerned. Naturally the adjoining teeth had approached each other so that the vacant space was about two-thirds the width of the *erupted* central. A skiagraph showed the missing central well up within the alveolus. In addition to the shadow of the central, and a little above it, was shown a peculiar shadow which we presumed to be a defect of some kind. A second picture was then taken in which this peculiar shadow again came out quite well marked, and after some thought I concluded it was a supernumerary tooth, and so stated. Space was made by separating the left lateral and right central to the necessary extent when in due time the missing central appeared, and finally was fully erupted. In the meantime the supernumerary tooth also came down, and so bore out the testimony of the skiagraph taken nearly eighteen months before.

"In Fig. 24 is shown the skiagraph of the upper incisors of a little miss of twelve. Two weeks previously she had received a violent blow in the face, and when she presented the left central was elongated nearly one-eighth of an inch, and the right nearly as much. The former was so loose that it was impossible to decide whether its root was fractured or not. The skiagraph demonstrates that the root is intact and that the injury is mostly to the process. Class 11.

"A lad of seven presented himself with the corner of an upper central broken off, caused by a fall. The shock to the tooth was so severe that the pulp died. Upon opening to the canal it was found that a piece of orange-wood fully one-sixteenth of an inch in diameter could be pushed through the foramen, and, naturally, to fill that root satisfactorily was almost, if not quite, an impossibility. A lead post was trimmed until it could just be forced through the end of the root, and by gentle manipulation it was finally decided that in a certain position it was about the desired length. It was then cut off *even* with the surface of the tooth, sealed in place with temporary stopping, and a skiagraph taken. This unfortunately was spoiled after it came from the fixing bath, but in the meantime I had seen that the post protruded slightly beyond the end of the root. It was therefore withdrawn, shortened the required length, and was then used to carry the gutta-percha root-filling to place, and allowed to remain in the tooth permanently, thus assuring me that the filling did not protrude beyond the root. Class 12.

"Skiagraphs of the antrum, or rather of a part of the antrum, may frequently be taken to advantage, but I do not include such cases in the true dental classes.

"Thus we have seen that the applications of skiagraphy to dentistry *are varied and numerous*, and, above all, *most satisfactory*. Consequently, *we may safely assert that in our specialty we cannot do our patients full justice or hold our own in the line of our profession, unless we give them the benefit of this new science*."

Following the technical directions given above by Dr. Kells, we append further matter calculated to inform both dentists and medical practitioners of the immense value of X-rays in this field of scientifically directed work. These cases have been published before, but *are not the less instructive* on that account. Transplanted to these pages they will meet eyes that would never otherwise see them, and certainly every surgeon, physician, and all who have teeth, should be made aware of the important facts. Therefore, without excuse or apology, we take these studies from current literature and insert them here.

"While the X-ray in dentistry is not usually employed in cases in which it is 'a matter of life or death' to the patient, its more frequent utility gives it a value of a high order, and its dental applications, while confined to a comparatively small portion of the body, are of rather wide range and will require as much skill on the part of the operator as work upon thicker tissues. For instance, the dentist must be able to so manipulate his tube and technique as to differentiate between the roots of the tooth and the bone which surrounds them, a task equal to any which confronts the physician. This is difficult, because as the root grows smaller toward its apex the bone proportionately thickens about the socket. Or, on the other hand, the dentist may have before him simply the location of a broken broach or a pus-cavity, tasks which are comparatively easy.

"The most frequent uses for the X-ray in dentistry, as brought out by Kells, Rollins, Price, and Clapp, are for locating unerupted

DENTAL SKIAGRAPH
by
Dr. C. Edmund Kells, Jr.

No. .... *Date*..

M..

Age ....

Examined for..

....

Make of Plate..

Time ....

Distance ....

Developer..

Tube ....

Remarks ....

....

....

PLATE 137.—Plate 8 of the text, showing form of envelope for filing and recording dental skiagraphs.

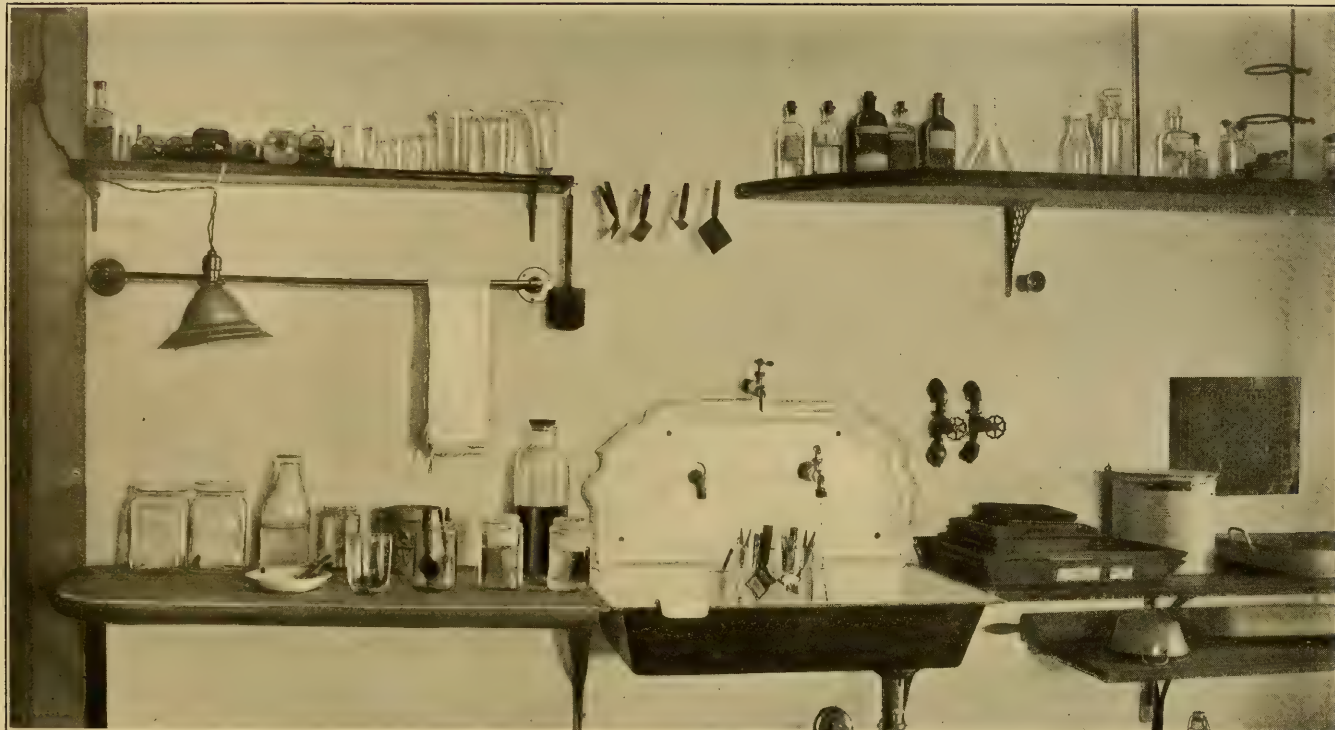


PLATE 138.—(9) Showing accessories for developing films as described in the text.

DENTAL SKIAGRAPH.

By DR. C. EDMUND KELLS, Jr.

No. 523 Date May 26 - 1901

Of Mrs H. W. B.

Age Adult ~~Upper~~ Lower

Examined for Molar root fillings and xtent of abscess.

Make of Film Seed's Special.

Distance 12" Time 1 Minute

Tube Gen'l Electric

Developer Metol - Hydro.

Notes

PLATE 139.—Fig. 10, showing a convenient card-mount with author's manner of filing record of the patient and radiograph. When filled and filed in an album for ready reference with an index, a given case may be found at will.

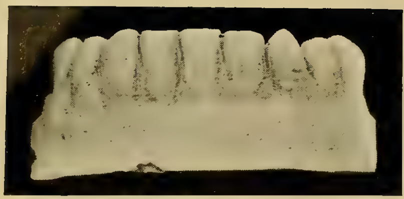


Fig. 11. At the left is a model of the lower teeth of an adult in which one incisor is missing, and on the right is the radiograph showing its absence from the alveolus.

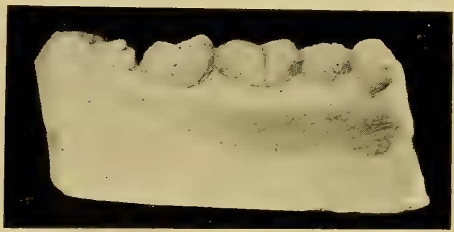
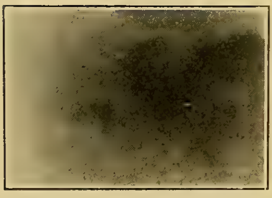


Fig. 12. Model of an impacted lower third molar.



On the left is the skiagraph of the above tooth, by which its removal was rendered easy. On the right is a photograph of the same tooth after removal.

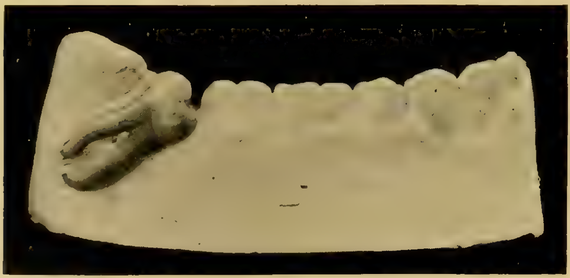


Fig. 13. Showing a model of the same lower jaw in which the same tooth is replaced after extraction to illustrate the difficulties which the radiograph solved.

Plate 140.

teeth, for ascertaining their position and the shape of their roots, for diagnosing fractures of the jaw, for locating foreign objects, such as a broken broach, for determining the depth of a root-filling, the presence and extent of an abscess, and the proportions of the antrum. The successful practice of X-ray work requires modern appliances, and a manipulation of them calls for one who is expert and accustomed to mechanical detail. To this extent the dentist is well fitted by the nature of his mechanical and digital acquirements at the very outset. Moreover, X-ray work being an electrical process, the majority of dentists are to a large extent familiar with the fundamental electrical requirements, and are all ready equipped with many appliances which may be used in the work. My best dental cases have been taken in from three to ten seconds, and the antrum in from ten to fifteen seconds. This compares with taking the hand in forty-five seconds, and the thorax in four minutes.

"Much has been said as to the best methods of preparing the film for a skiagraph. Ordinary film is used for this purpose. One encloses it in black unvulcanized rubber. Another wraps it in paper with the edges glued. In taking a picture of the lower jaw in mouths profuse with saliva, and with a small coil which requires a minute or so exposure, the rubber wrapper is invaluable. But with a large coil with which the work can be done in a few seconds I have simply enclosed the film in two thicknesses of black paper. Two layers of paper are necessary to exclude the light, and I have not yet required so long an exposure that the inner layer was ever moistened.

"Before closing I will call attention to a class of cases in which the X-ray is of high value. It is frequently necessary to open into the antrum for treatment and drainage. For this purpose it is desirable to open at the most dependent point, and exactly flush with the floor. A point between the second bicuspid and the first molar is usually selected for this purpose, and a skiagraph taken through this region will indicate the exact point for making such an opening. This is an easy matter. A rather large piece of film is wrapped and placed well back in the mouth. It is held in contact with the teeth and palate, and *the tube is placed at an angle of about forty-five degrees up and back.* This will produce a picture with the least distortion of parts. The bone being rather thick, from ten to fifteen seconds will be required with the tube fifteen inches from the face. Less time will be required if the tube is nearer. An examination of recent skiagraphs will show with what precision this can be done. The beginner in X-ray work should make up his mind that he is entering a field that requires practice, and yet I know of no more fascinating work than this. From the turning on of the current to the printing of the skiagraph, it is teeming with interest, and no other procedure in dentistry gives more pleasure and profit to the operator than X-ray work." (CUSTER.)

"For preparing the plate or film for the purpose several methods have been suggested. To my mind, no method that I have heard of approaches in convenience and simplicity the following: It consists in simply placing a large piece of specially prepared X-ray film, which is quite stiff, between two layers of unvulcanized black rubber, making the rubber touch around the edges where dentists know how sure it will be to cling. This can now be cut to the desired sizes with a pair of shears, and simply pressing the rubber together where you have cut seals a perfect joint. This is perfectly impervious to light and moisture, and offers almost no resistance to the X-rays. I put a piece of X-ray bromide paper also in with its face to that of the film, thereby getting a photo direct, and also protecting the sensitized surface of the film. Occasionally, it is an advantage to secure the plate with a special plate-holder, but very seldom do I think it desirable or necessary, the films prepared in the way I speak of are so convenient. You can bend a corner over anywhere, thereby making the film any desired shape or size, and, of course, the rubber adheres to itself and holds it firmly. The film can generally be held in place with a finger to get the best results.

"You will observe a number on each side of the slides exhibited. This is done by placing little figures on the outside of the wrapper over the film. They are made of fine copper-wire, prepared in advance, and stuck on with gum labels. It is a great convenience for keeping records without danger of getting negatives mixed.

"I have a very complete system of keeping all the records of each case, upon the envelope used as the negative preserver, which I will pass around. Note especially that the angles of the rays, the teeth, and the plate, to each other are kept in each case. This is very important and valuable since by it you can at any time determine the exact dimensions. Before proceeding with the practical cases I want to advise any intending investors to get a small glass-top table on large, rubber-tire casters, or wheels, for keeping your coil and accessories, which are few, upon. We will now see some lantern views of practical cases and one or two typical pictures will suffice in each of several classes of cases in which the Roentgen rays are specially well adapted for diagnosis. Unfortunately a great deal of the detail and information is lost as compared with looking through the negative itself. Photos, even contact prints, lose about half their detail. In good negatives even the cellular structure of the bone is distinctly shown. This is mostly or entirely lost on the screen or in the half-tone used for illustration, so you will have to make a great deal of allowance.

"For the location of unerupted teeth the X-ray is simply *perfection*. Fig. * shows the condition of the superior arch of a boy at ten years of age. Two generations preceding, on his mother's side, had been lacking the superior laterals. She presented him to have steps taken to prevent the shedding of his deciduous laterals to make them

* In joining together the following extracts from several interesting lectures by Dr. Price we have deemed it useless to insert the numerous small radiographs which show so poorly in reproductions, though his figure references have been left standing in order to keep the text intact.

permanent. You can scarcely imagine the joy of that mother, who herself suffers considerable disfigurement from this cause, when she saw the radiograph showing the development of these teeth that had been the object of her cherished but abandoned hope. The next figure illustrates the condition in a case of delayed dentition of the bicuspids. The cuspid has been erupted for some time and the first deciduous molar shed by this eruption. This superior arch is exceedingly retracted. The radiograph shows that but one bicuspid has formed, and it is thrown out of its course by about twenty degrees. It is absorbing the anterior buccal root of the first permanent molar. A course of treatment is quickly suggested.

"In the next figure is a typical example of the appearance of cases where a permanent tooth fails to form and the deciduous is retained. In this case an inferior deciduous molar. A lady of about thirty years of age discovered that she still had a baby tooth and felt so ashamed of herself that she hurried to the office to have it extracted. The radiograph settles all hope of it ever having a successor. I will now show you a wonderful picture demonstrating the very early calcification of the enamel of the permanent teeth. It is taken of the superior arch of a baby boy of fourteen months, who has no deciduous teeth erupted yet in this arch. The radiograph shows not only the development of all the deciduous teeth, but also the commencement of calcification of the permanent centrals. But this is not all. While his father is lacking his permanent laterals we can see clearly in the negative, which was a ten-second exposure, even at this young age the crypts forming for his permanent laterals. I know of the joy of that boy's father at this information, for he is my boy.

"An example of lost teeth is shown in the next figure, which indicates the whereabouts of the missing bicuspids. There are very many cases of this class. The next figure shows a lady's superior arch at about thirty years of age. When this picture was taken she was still waiting for her permanent teeth to erupt, but she need not wait longer, for this lone second molar is all she is to have on that side. Five teeth are lacking on that side and three on the other. In no class of cases is this means of diagnosis of more frequent service than for exploring the various deep pathological conditions. For example, the extent and location of abscesses, the direction and path of the fistula, and of very great importance, the most dependent point of the abscess. This next picture shows the appearance of a blind abscess at the apex of an inferior incisor. It shows which tooth is affected and that no teeth in this vicinity have root fillings to suspect as imperfect.

"In the next figure we have some information regarding a case of neuralgia of uncertain cause of years' standing undoubtedly caused, as proven later, by the blind abscess at the apex of the first superior bicuspid. The abscess was evidently caused by imperfect root-filling, which is clearly shown to only extend half way to the apex. On opening up the canal I found putrescence in the apical half of the canal. This negative shows beautifully the cellular structure of the bone.

The next picture, Fig. —, shows the same root filled to the apex. The blind abscess was drained through the buccal wall of the process. These abscesses vary greatly in extent and their exact extent is clearly shown in good radiographs, as for example in this picture, Fig. —, which shows a blind abscess of considerable dimensions, and of years standing, during most of which time it has been almost continually under treatment, so the patient informed me, through the root-canal of the lateral where it had its inception. In this next picture we have an exceedingly large abscess, and also one of long standing. It had a fistula beside the second bicuspid. The dentist sending the case for radiographing had labored faithfully, but with unsatisfactory results, to cure it. A crown on the lateral had been destroyed to examine the root-filling beyond it, and the second bicuspid had been extracted and replanted in search of exostosis. The radiographs taken in sections, show the root of the lateral to be largely absorbed and a series of pockets difficult to drain between the roots of the various teeth. It also shows the abscess to extend beyond the anterior buccal root of the first molar.

"The picture next before us shows a remarkable change of bone-structure taking place around a superior central incisor, one that had, a couple of years previous, received a hard blow, since which time it has been constantly elongating, though it is very solid in its attachments. The negative shows clearly the old base for the apex, from which it has advanced about three-sixteenths of an inch. It is an interesting study in pathology. The bone, though forming an unusually firm attachment, is evidently less dense than normal, and slightly honey-combed in structure. The peridental membrane is almost obliterated. In the next picture (Fig. 17) we have another blind abscess with its evident cause, viz.: Imperfect root-filling. The case was of thirteen years' standing and had received extended treatments. I amputated the tip of the root, without extraction, at the point where the root-filling ended as shown by the radiograph, and with splendid results. The next picture shows the same tooth after the root amputation. In the next picture we see how beautifully the bone has adhered around the stub of one of these amputated roots. This amputation was made in January, 1896. The patient claims it to be the strongest, solidest tooth she ever had. In the next we see a broken broach protruding through the apex far into the tissue.

"In this picture (Fig. 21) we see much of interest. The radiograph was taken to locate a piece of a cambric needle which the patient had broken in the root while trying to relieve an abscess. It was thought to have been forced through into the tissue as the apex was found open. It is easily seen lodged in the root, which was evidently bifurcated. This picture also shows beautifully the relation in this case of the teeth to the antrum. You will observe that the roots of the second molar penetrate nearly half way up through that cavity. The value of X-rays in Orthodontia *is almost beyond*

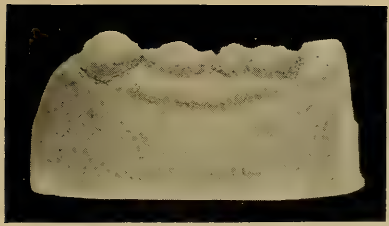


Fig. 14. At the left is the model of lower teeth of miss, aged 14, with an abnormally shaped second bicuspid. The radiograph on the right shows the same in situ as seen by the X-rays. Its single root proves it to be the second bicuspid and not a retained temporary molar.

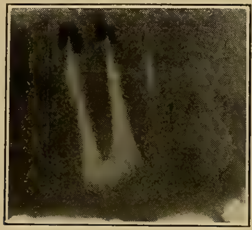
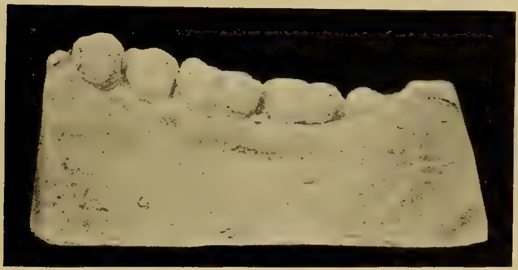


Fig. 15 shows a lower incisor. The alveolar process has been entirely destroyed by an abscess and the apex of the root has been absorbed.



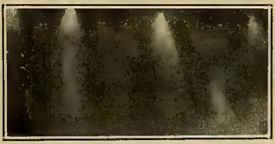


Fig. 16. The model shows a second molar which was extracted and replaced. The radiograph at the right was taken a year after and shows the roots to be perfect, no absorption having occurred.

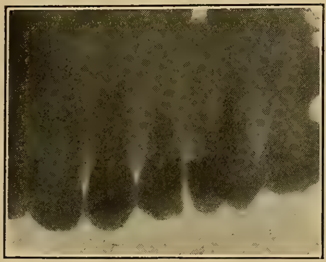
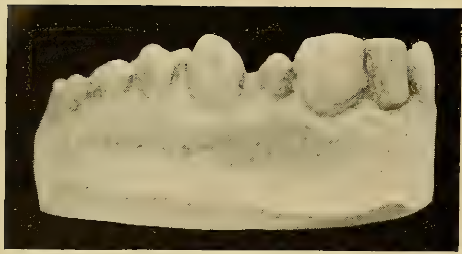


Fig. 17. This shows indistinctly in the reproduction the root of a first upper molar in which a broach has been broken off.

Plate 141.



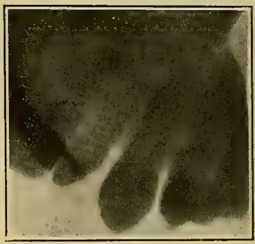


Fig. 18. The model at the left is that of an adult with a malformed left upper lateral. The skiagraph at the right shows that the tooth has a sufficient root to justify a crown.

This (Fig. 19) is a root which was crowned and tubed to share with its opposite mate the support of nine teeth. It failed. Had it been skiagraphed first it would not have been so taxed.

Fig. 20. The model at the left shows the remains of a third molar. It was supposed to have been extracted a year previous and was entirely invisible, being covered by the gum. By the aid of the skiagraph it was easily discovered and removed. The picture on the right shows the root of a lower bicuspid which was invisible to the eye. The X-ray made it easily removed.

PLATE 142.

Fig. 21. At the left is a model showing the left central unerupted in a child of 12, and no signs of it could be discerned. The skiagraph at the right shows the missing tooth well up in the contracted space. The shadow of a supernumerary tooth was also revealed. Space was made and the central finally erupted. The supernumerary also came down and confirmed the skiagraph.

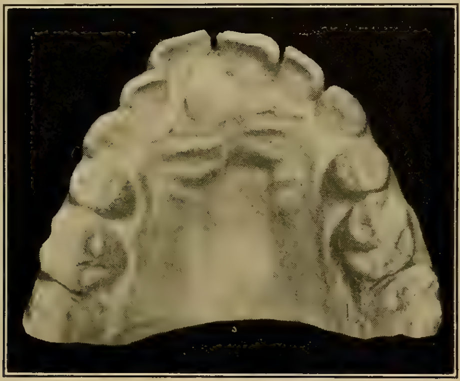


Fig. 23. This model shows the central erupted with the supernumerary tooth behind it. The model was made 18 months after the above illustrations and exhibits the beautiful certainty of working with the light of X-rays.

Fig. 24 shows the upper incisors of a girl of 12. She had received a violent blow and it was a question whether the root was fractured or not. The skiagraph demonstrates that the injury is chiefly in the process and the root is intact.

PLATE 143.

calculation, for it enables us to see just how our force is being expended. Probably the greatest factor in that work is to move the roots as well as the crowns. In this picture (Fig. 22) we see an attempt to draw two teeth together when alas only their crowns have been tipped toward each other. This next picture (Fig. 23) shows the commencement of a case where separation the width of a tooth (one having been recklessly extracted) is required. And in the next picture (Fig. 24) we see how well this has been accomplished. Unfortunately, time only permits of one example of each of a few classes of cases out of a great many. The next figure shows beautifully the fit of these crowns and the depth of a pyorrhœa pocket. The radiograph shows a perforation in the wall of the root of the first bicuspid through which cement has been forced into the tissue producing the suppuration and absorption, supposed to be a pyorrhea pocket. In this next picture (Fig. 26) we have an example of the service of the X-rays in determining the location of third molars. This one is not erupted at all, and lies at just right angles to its proper position as shown by the second molar. It would certainly be a difficult one to extract if you did not know its position."

"There is no field of application in which the X-rays will bless so large a number of mankind as in dentistry.

"The serious lesions and deformities of the teeth and oral cavity and adjacent parts are usually deep seated and their source and even location frequently entirely obscure. For example, what is the cause of this chronic empyema of the antrum? The lady is about seventy and the case has had skilful treatment for a couple of years. You see quickly the cause in this lantern-slide. It is a piece of a root partly perforating the antrum and which was buried deeply under the soft tissues. The X-rays have a much wider range of application in antrum troubles than has been recognized. This next case is of special interest because a malpractice suit was brought against a dentist claiming that in extracting the badly decayed roots of a molar tooth the operator forced one of them through into the antrum causing an acute empyema. This skiagraph shows clearly the antrum, but there is no root in it. This next slide, however, shows clearly the cause of the trouble which is the imperfect root-filling in the bicuspid. As you see, the chamber from which the pulp of the tooth has been removed has not been filled to the apex of the root. This almost invariably develops an abscess, and which in this case, as frequently occurs, has broken into the antrum. All the surgeons in the audience know the necessity of draining the antrum if possible from its most dependent or lowest point. But how can this be determined clinically, for the lowest point has not a universal or definite position? For example, in this case (Fig. 4) the lowest part of the floor of the antrum is between the first and second molars, but there is an anterior chamber or department separated by a high partition, the lowest part of which is over the first bicuspid. Observe how the roots of the molars penetrate the antrum and hence how easy for an abscess at the apices of these roots to drain into it. In these cases the dense plate of bone forming the floors of the antrum is carried up over the apices of the roots, as, for example, this handkerchief when placed over this pencil forming a cone which in case of an abscess of this root draining into the antrum would probably be perforated at its apex. Suppose this first molar to be extracted to drain the antrum, it would remain full of fluid to the level of the apex of this cone, while a perforation into the antrum through its buccal wall between the roots of the first and second molar would produce the desired result and save a valuable tooth. And right here I must protest against the common practice of sacrificing valuable teeth for this purpose. It is not necessary, for the above operation is much better. This particular case was skiagraphed to determine the location of a piece of a needle which had been broken by the patient in the tooth and it was thought to have been forced through the apex into the tissue as it could not be felt inside the tooth. The skiagraph shows it plainly within the tooth.

"The next (Fig. 6) shows another case of obscure antrum trouble which evidently comes from a putrescent root-canal and abscess of the bicuspid. Notice how low the floor of the antrum is at its lowest part. These are only a few examples of antrum complications. Frequently the antrum becomes enlarged in a particular direction by the suppuration, and by skiagraphing both sides at the same angles and extent of the absorption can be determined. By this means the exact location and boundaries of an abscess in the process resulting from putrescent pulps can be determined and after they are very obscure even though producing great disturbance as in this case. (Fig. 7.) The patient had suffered for about three months from an obscure neuralgia and an examination of the teeth by different dentists revealed nothing abnormal. Several skiagraphs were taken of the teeth on the side affected and this blind abscess was found on the first inferior left bicuspid, which, when treated, entirely and permanently cured the neuralgia.

"One of the most difficult operations is to make an artificial fistula to drain a small blind abscess at the apex of the root. The skiagraph is of great assistance not only in locating the abscess, but also in showing whether you have struck it. This is shown *by placing a lead-wire in the fistula and skiagraphing.* In this slide the lead-wire in the picture marked 367 shows that the first attempt failed. The other picture shows that a second attempt was successful.

"In orthodontia, which is the correcting of the positions of the teeth or correcting of the features by changing the positions of the teeth, the X-rays are of great value to determine the *positions of the roots.* For example, it is desirable to move all the upper anterior teeth and the bone around them forward to correct a depression of the upper lip. The difficulty is to carry the roots *en masse* and not to simply push the crowns apart. This case (Fig. 21) shows the position of roots at starting, and the view to the right shows the roots successfully carried apart without tipping the teeth.

"You doubtless all know of the difficulties and complications attending the erupting of the third molars, or wisdom teeth so called. This skiagraph (Fig. 22) shows the position of a typical impacted one, which was entirely hidden in the flesh and bone, not having erupted yet and producing very serious trouble. You will see the mechanical difficulty of extracting it, since it is engaged or locked against the second molar. The dentist sending the case, after seeing the skiagraph, operated by extracting the second molar first, and then the third, and then replacing the second molar after removing its pulp and filling its roots. Result excellent. The next shows a case with an external fistula on the ramis of the jaw, diagnosed by different surgeons as coming from an impacted third molar, and was operated on accordingly for its removal, but unsuccessfully. The skiagraph was then secured, which shows that not only the third molar has never formed, but an abscess at the root of the second molar which has a putrescent pulp, and which proves to be the cause of the whole trouble. There is no difficulty whatever in locating unerupted teeth by means of rays. For example, this patient, a lady over thirty, presented without either permanent cuspids, and the bony process was receded, making it seem quite probable that they had never formed, but they are both clearly shown in Fig. 24 just beneath the surface, and will be speedily regulated to their proper position.

"These lantern slides, unfortunately, do not show the excellent detail, either of the original negatives or of prints made from them. You may have observed how much more faithfully the teeth are portrayed in fine dental negatives than in skiagraphs taken of the whole head, for in the latter case they are duplicated and blurred by the shadows of the teeth of both sides of the arch falling together. The detail necessary to bring out an abscess, for example, could not be secured in that way.

"This next slide shows the condition of a girl at fourteen who has retained all the second deciduous molars. Why have the second bicuspids not erupted? And will they ever? are questions requiring to be answered, and could only be answered heretofore by a destructive operation. The skiagraphs reveal a strange condition. The second bicuspids are forming in the superior arch but not in the inferior. Of those above the roots are just beginning to form, though these teeth have already caused the absorption of the roots of the deciduous molars. While in the inferior arch no biscupids have formed, there is present on the left side the formative organ, and in position, and it may yet perform its function.

"In Fig. 3 you see the location of a missing bicuspid. Remember the soft tissues are not shown in the picture, but only the teeth and bone. Clinically the condition suggested that the missing bicuspid had not formed. You see it clearly inlocked between the first molar and the first bicuspid. You see also the developed crown of the second molar still without roots, and the developing crown of the third molar.

" Sometimes teeth wander far out of their proper position. Fig. 4 shows a permanent cuspid in the floor of the nares and in the posterior part of the hard palate, with its cusp just in the median line. The patient is about twenty years of age. It also shows a small supernumerary just inside and between the central incisors.

" Fig. 5 is even more remarkable, for it shows a fully developed permanent lateral root on which no crown has formed (a), and a fully developed central crown on which no root has developed (b). In this case the right permanent central and the left cuspid are nearly touching. The patient is a girl of fourteen years. The left central and lateral are missing, and there is to be seen between the right central and left cuspid what the mother remembers to be a temporary tooth. The skiagraph shows this supposed temporary tooth to be a crownless lateral with root perfectly formed, and also shows the rootless crown of the missing central with its incisive edge engaged against the root of the right central. This patient is of necessity quite disfigured, but the information suggests the proper course for the best correction of the error. This condition is the result of a bad fall when a baby.

" Fig. 8 shows a remarkable condition. The patient had suffered from a dead pulp in the left central, presumably caused by percussion in an argument about a year previous. After treatment the canal could not be closed without extreme discomfort and the tissue at the apex of the root seemed to be abnormally sensitive. The dentist in charge brought the patient for a skiagraph, which shows a fully developed cuspid tooth lying against the root of the central. It has caused a complete absorption of the upper third of the root of the lateral. The patient had a gold crown on the left cuspid, and he said he was sure it was on the permanent cuspid. The root of the deciduous cuspid, which proves to be the tooth crowned, is extensively absorbed on its mesial side. A piece of broach was placed in the canal of the central for skiagraphing.

" Fig. 9 shows the cast (c) of a girl's inferior jaw at fourteen in which no teeth have erupted back of the first bicuspid since the extraction of the first permanent molar, which was done by force when the patient was only six years of age, and was attended with great struggling, so I am told. The next view (a) is a skiagraph of the condition, and shows the position of the second bicuspid and second molar. The second bicuspid is lying on its side in the bone, about one inch back of its proper position, and the second molar is in proper position back of it. The treatment for correction is quickly suggested, and accordingly I have placed a rigid anchorage appliance on the anterior teeth, and have, after anæsthetizing and incising the gum tissue, inserted a tapped screw-post into the displaced second bicuspid. Fig. 10 shows work (a) in moving teeth bodily where the anterior teeth had to be extruded to correct an intruded bite. It also shows (b) that the structure of the new bone is identical with that elsewhere. This case also demonstrates beautifully by comparison the improvement in skiagraphing when the penetration of the rays is properly adapted to the condition. Fig. 11 demonstrates the value of the rays for locating teeth that are supposed not to have formed. The missing permanent cuspid is clearly seen (a) inlocked in the process. The next view (b) shows this same permanent cuspid regulated to its proper position and retained with platinum wire. This patient is a young lady about eighteen, and on account of the permanent laterals never having formed, this correction is of very great value to her, for her features have been very greatly improved by her dentist since he secured this information.

"Fig. 12 (a and b) shows how much nature had corrected the position of a locked bicuspid in sixty days after it had been released by separating the teeth that are locking it. Test skiagraphs had first been made three months apart to ascertain whether Nature would make any progress in correcting it unaided, and it was found that she would not. This case is of special value because the patient suffered from a badly intruded upper bite partly caused by this condition, only one bicuspid having formed.

"When a case presents with symptoms of a pericemental inflammation and the history is uncertain, as it usually is, the ideal procedure for both the patient and dentist is to first skiagraph the condition and find out the location and extent of the lesion and its cause. Then he can go directly to the trouble with a minimum of time and effort and treat the condition consistently and intelligently. He can take the skiagraph and develop the piece of bromide paper put in with the film all within one or two minutes. Fig. 14 shows two such cases. The first (a) shows the location of the lesion which is causing the neuralgia to be about the apex of the second bicuspid, and its cause is clearly evident, viz., that the root has only been filled about half way to the apex. This tooth did not respond abnormally to percussion. The second picture (b) shows a similar case, and the trouble is about the apex of the mesial root of the first molars, which root is not properly filled to the apex, and the root is a little absorbed. This condition of absorption of the apex obtains in almost all chronic abscesses whether blind or not, and, in my judgment, can usually be best treated by root amputation without extraction.

"We will now turn our attention to the dentists' graveyard, root-canal fillings, where so many cover up defective, careless work, trusting it will never come to light, and often reminding the patient that when this tooth gives trouble again it will have to be extracted. Humanity should thank God for a new light that will go into these dark places and show up what is often criminally careless or wilfully bad work in filling roots. True, it is often impossible to properly fill roots, but if all were as well filled as possible, those imperfectly filled would be only those with so small a canal or so little of it unfilled that the woes of humanity from this source would be infinitely less than they are. Figs. 17 and 18 show collections of good and bad, mostly the latter, however. *When skiagraphing comes to be used generally even a little in dentistry there will be a great improvement in the work of filling root-canals.* Fig. 25 gives an example of the use of the rays in opening through a filling or root-filling to an unfilled or partially filled root-canal. The first view (a) shows this case as presented with a blind abscess at the apex and a gold filling. The root-filling was done twenty years ago. You all know it is like trying to thread a needle at arm's-length in the dark to drill straight through a hard substance to an open canal in the root. Having the skiagraph before me I could tell by measurement when I had gone far enough, but could not tell the exact direction. To ascertain the relation of my drill to the canal two skiagraphs were taken at different angles with the drill in place, and were developed at once. As you see (b and c) my drill was only out of line about the width of the drill mesially, as seen by the centre view, but twice that distance lingually. It only took a few moments to get this information, and, after getting it, I was able to go as directly and quickly to the unfilled pulp-canal as if I could see it. Fig. 26 shows the use of the rays in a branch of dental surgery, viz., root amputation. The first view (a) shows the condition before operating. There was a large abscess involving both roots. This had been skilfully treated, but could not be cured by ordinary means, because of the diseased condition of the roots of both teeth, which were accordingly amputated without extraction. The second view (b) shows them after amputation, and the third view (c) shows the extent to which Nature has filled in this abscess cavity with new bone in thirty days. Fig. 27 (a, b, and c) shows the use of the rays in reaching an abscess through the root where the canal is too small to find. I drilled in the right direction as far as I knew I was safe, and put in a piece of broach and skiagraphed in two directions, as in Fig. 25. In this way I was able to drill the whole length of the tooth in safety, and, as you see by the final test, went straight through the apex and not through the side, as I would have been most certain to do without the help of the rays. Fig. 28 shows a case of root implantation less than three years after the operation. The root had been crowned with a logan. By comparing the density of this root with the others you will observe that the lime-salts have been almost entirely absorbed from it, which accounts for its lack of rigidity. Nature evidently considers it as an irritant and is trying to absorb it." (PRICE.)

Another dentist reports:

"Both of the following patients suffered with neuralgia. In the first case the radiograph gave a negative result, which was, however, of value because it demonstrated that the pains were not of dental origin. The teeth were all perfect and unquestionably in a healthy condition, and it had been suspected that there might be an impacted wisdom tooth. The picture disposed of this theory. In the second case the neuralgia was equally severe and obscure. A skiagraph was made and disclosed the presence of pulp nodule in the root of the lateral incisor, the upper half of the canal showing clear, and thus indicating the presence of live soft tissue only. The canal of the cuspid is shown to be clear, while a root-filling in the molar shows a dark shadow. The pulp of this tooth being removed the pain disappeared.

"Without the picture there would have been no more reason for opening the lateral incisor than for so treating either of the adjacent teeth. There are conditions in dentistry that may be positively diagnosed by use of the X-ray which could not be known by other means, except by sacrificing the teeth." (STEPHENS.)

Also another:

"With us it is a very common thing for all abnormalities that present themselves to be immediately settled by a skiagraph. The nervousness of the patient from a long sitting has practically been overcome, in that with ordinary plates the exposures have been diminished to only one or one and a half minutes. I believe with the emulsion that is put upon the isochromatic plate and the introduction of a proper screen, we could get better pictures." (VAN WOERT.)

Position of Film and Tube.—An English dentist, speaking to the Odontological Society, remarked as follows:

"The anatomy of the mouth, more particularly in the relations of the roots of every individual tooth to the inner surface of maxilla or mandible, requires a good deal of attention in order to be able to place the film so as to catch the shadow of the roots under examination without superposing on that shadow that of a neighboring root. The curvature of the palatine surface of the maxilla, where the alveolus rounds off into the hard palate is very difficult to negotiate, and usually results in a compromise; viz.: if the general curvature of the film when moulded to the curve of the alveolus, be roughly estimated as making *an angle of forty-five degrees with the axis of the root, it will be necessary to pass the rays through the teeth at an angle of forty-five degrees* in order to maintain a perpendicular direction. The amount of distortion obtained in large work on a bent film and with slanting rays would obviously be very considerable, but in dental work, when the skiagraph is made of so small an object as a single tooth, a skilled arrangement of the film and tube reduces this difficulty to practically nothing. A clamp to hold the film steady was once considered desirable, but *no mechanical clamp answers the purpose so well as the finger of a skilled and steady assistant holding the film against the maxilla or mandible, while with the other hand making counter-pressure outside.* The head of the patient is best fixed for exposure in the ordinary head-rest of a dental chair. Owing to the short exposures and the character of the work, it is perfectly safe to bring the tube to within ten inches of the plate, and this distance is recommended by some workers. Others employ fifteen inches."

While nearly all dental examinations use the radiograph on account of its superior adaptability to the work, yet sometimes a preliminary observation with a fluoroscope may be desirable. The modified fluoroscope designed for use within the buccal-cavity is an aluminum tube, containing at the opposite end a small mirror inclined at such an angle as to reflect the shadow from a miniature fluorescent screen in the wall of the tube to the examiner's eye. In the course of time improvements in the use of the dental fluoroscope may make it of greater service than it has so far been considered. Its limitations are, however, obvious.

CHAPTER XXXIV

X-RAY DIAGNOSIS IN DISEASES OF THE CHEST

Eye-Training for Pulmonary Fluoroscopy. Study of Diagnostic Factors. Plan of X-Ray Examination of Thorax. Comparison of Fluoroscopy with Physical Methods. Determinative Tests. Studies in the Alphabet of X-Ray Readings. Diagnosis of Pulmonary Tuberculosis. Detection of First Stage of Phthisis. Diagnosis of Pus. Function of Repeated Examinations. Diagnosis of Diseases of the Heart and Aorta. Heart Reflex. Chronic Pericarditis. Slow Pulse. Aneurism.

Eye-Training for Pulmonary Fluoroscopy.—So important is the subject of pulmonary diagnosis that too much can hardly be done to put the observations of different workers before the practitioner. *Comparison* of teachings will perfect individual skill, and repetition of even familiar facts will often bring out some detail that was missed before. In fluoroscopic examinations of the chest the danger of dermatitis is absolutely *nil.* No special precautions are required. Healthy lungs are translucent. Normal shadows must be studied in the healthy, and compared in the young, middle aged, and old of both sexes—and in persons of different degrees of muscular development from obesity to emaciation. Shadows of the scapulæ, the anterior axillary fold, and the nipple, when seen, can be distinguished from deep tissues by having the patient move the arms. While the very earliest deposits of tubercle may not yield any appreciable shadows, yet all that can be said on this subject of early recognition must stand or fall according to the personal equation of the observer. The *eye-training* needed for diagnostic work in suspected incipiency of phthisis is not the possession of the physician *per se. Practice* alone can cultivate it, and till it is cultivated it does not exist.

Advanced tuberculous changes cast definite shadows, and a few men of great experience have also been able to assert a diagnosis from the radiograph before any physical signs appeared. In some suspected early cases, moreover, when experts have failed to find evidence on the screen, time has shown that no disease appeared later.

When ordinary diagnosis has detected disease at one apex the screen has sometimes found it to be bilateral also. The more advanced the disease the darker the shadow, especially when caseation is in progress. Cavities are indicated by light areas in the midst of dense shadows. Fibroid changes and adhesions only create shadows after they have attained a definite density, and these shadows differ considerably from those cast by tubercle. Emphysema is indicated by exceptional transparency of the affected part of the lung, as air is more easily penetrated than any tissues. In early dry pleurisy only a very faint shadow can be detected. Serous effusion causes a dim blurring of the rib shadows but does not hide them, and the upper margin of the fluid often shows a clear line of demarcation. Study the differentiation of these degrees of shade.

Take a wooden sample-bottle such as are used for mailing drugs and half fill it with water. Hold it in front of the fluoroscope and turn it various ways and tilt and shake it. Profitable study of such shadows as are caused by water in the pleural cavities can be improvised in this way. The water has a shadow of its own. Purulent effusion causes a darker shadow. If sufficient in quantity it may cast a very dark shadow. The same study of it can be made as with water. Secure a tube of pus removed from a case of empyema and study it with the screen. It will present nearly the opacity of bone. Blood and serum should be put to the same tests, and they make lighter shadows. This kind of study will rapidly develop diagnostic confidence and skill.

Abscesses, like caseating nodules, cast very dark shadows, and even through thick tissues, such as the kidney, caseous tuberculous nodules have been clearly discerned. Enlarged and caseous glands cast recognizable shadows. In the chest the detection of morbid growths and aneurisms is quite accurate with the X-rays. To study and arrive at diagnostic expertness in these fields of examination the physician can artificially create most of the densities and keep at hand a series of comparative tests which will rapidly familiarize him with clinical conditions, and further practice will develop the expert. These are some of the rudimentary generalities of the subject of thoracic examinations. We will now study certain specific diagnostic factors in fluoroscopy of the respiratory organs. Their importance is great.

"The diagnostic factors of a fluoroscopic examination of the thorax are *light, shadow,* and *motion.* Upon these three rests the most elaborate examination by X-rays." But when we apply these simple factors to differential diagnosis we need not only the physician's knowledge of anatomy and disease, but must also have ascertained by other methods of examination an idea of the probabilities in the case. X-ray shadows are not like maps with names engraved on them to identify lesions, but with a medical knowledge of what ought to produce a certain appearance we may then say that the appearance (when seen) has this probable cause behind it. Exclusion furnishes the last refinement to the final diagnosis. Speaking of the fluoroscopic chest-picture Crane has said:

"Shadows of varying density may appear, abnormally clear areas may develop, the heart or diaphragm line may become displaced, obscure or invisible, and the motion of the diaphragm may be restricted or reduced to zero. These appearances must be interpreted in any given case to mean infiltration, consolidation, cavity, effusion, infarction, etc.; and these conditions must be summed up with medical skill and further interpreted to mean tuberculosis, pneumonia, pleurisy, œdema, etc. The diagnostic resources which lie in the fingers and ears of the practitioner command our respect, but such is the supremacy of the *eye*, and such the importance of things seen, that even after a careful physical examination the fluoroscopic image comes like a revelation to the observer."

With these facts in mind we will now consider how practised clinicians apply them.

Plan of X-Ray Examination.—To save time and avoid overlooking points adopt a routine system. First make the usual physical examination. Examine the sputum if there is any. Lastly, with outer clothing removed, make the fluoroscopic inspection. If any condition is discovered which is of interest to record, or is too obscure for the fluoroscope and requires a finer definition, make a radiograph. Full technics for the most rapid and convenient fluoroscopy of the chest with intercurrent radiography are taught in Chapter XV. Refer to them and proceed accordingly. The specialist doing routine work of this kind is advised to keep his tube connected up in a tall upright case, which preserves it from dust and accident, while always ready for this particular use by simply opening the case door. See Instruction Plates of the uses of the Skiameter, Nos. 146, 147.

Inspect the upper, middle, and lower thirds of the lungs, both front and back. Compare like parts on opposite sides. Compare different areas of the same side. Note the heart shadow and the diaphragm line. In a doubtful case compare the view with that of a healthy subject. Frequently also refresh the training of the eye by studying the chest in health.

The difference between the front and back views is due to getting different structures in closest relation to the screen. The most distant shadows are diffused and diminished. The thin front ribs cast but little shadow, and when the back ribs are distant from the screen a fairly clear view of the area of the lungs is obtained. The dark line of the spine cannot be evaded, but the scapulæ can be got out of the way by extending the arms over the head. If in a rare case the female breast hinders the contact of the screen have the patient draw it as much aside as possible. When the back is against the screen the thin front ribs and sternum are distant, and thus cast only a diminished shadow. This may give the best view of some diseased areas. After a little practice lay out a systematic plan of examining the different areas in regular turn and then adhere to it.

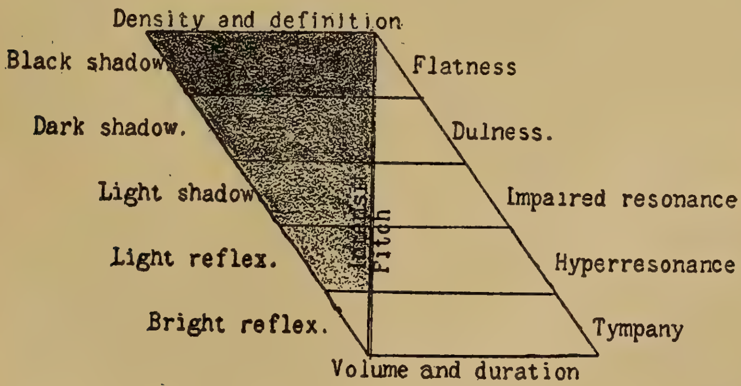
Comparison of Fluoroscopy with Physical Methods.—"When the X-ray examination is preceded by the physical examination an opportunity is given to compare and supplement the results of one method by the other. The *end*-results must agree if the phenomena observed are correctly interpreted, but the information elicited by inspection, palpation, percussion, and auscultation is not in each case *coextensive* with the information gained by the fluoroscope, skiameter, and skiagraph.

"By *palpation* we may feel the rhonchi, the friction fremitus, and the vocal fremitus. The rhonchi and friction fremitus denote conditions which give no sign on the fluoroscope. The vocal fremitus is increased over consolidated areas and decreased over emphysematous areas, and in this it agrees exactly with fluoroscopy. If, however, we draw the conclusion that whenever the vocal fremitus is increased we should find an increased density in the fluoroscopic shadow and vice versa, we will be disappointed. In pleuritic effusions we find the vocal fremitus decreased or absent, but we find the fluoroscopic shadow dense and unmistakable. The same is true of pleuritic thickenings, of filled cavities, and of consolidations with occlusion of the large bronchi. Moreover, the vocal fremitus is increased over dense-walled cavities which would give a ringed area of light-reflex upon the fluoroscopic screen. In these states it could be said that the results of palpation are not parallel with those of the X-ray, but the narrow limits of palpation must be kept in mind and only its positive data considered.

"As we reduce fractions to a common denominator, we may reduce light and shadow to the common terms *increased transparency* and *decreased transparency*. Either *increased* or *decreased* transparency may differ in intensity, position, form, and extent. Motion may likewise differ in character and extent and in the method by which it is elicited. In those pulmonary diseases in which there is an increased amount of air in the lungs on one or both sides, we would expect to find with the fluoroscope an increased transparency in one or both lungs. This is discovered to be a fact in asthma and emphysema. In those diseases in which there is a diminished quantity of air in the lungs we would expect to find a diminished transparency to the X-ray. This we find to be true in congestion, pneumonia, tuberculosis, and many other diseases.

" Focal diseases, such as abscesses, infarctions, and tumors would be expected to cast shadows proportioned to their size and density. It is the density of a focus-lesion which determines the density of its shadow. There must be *more substance* in the path of the ray if it *diminishes* the *transparency.* Lack of air in the lungs would not alone account for the decreased transparency during *ex*piration. The settling together of the lung-tissue in expiration contributes something to lung-density, but there must also be *an increased quantity of blood and lymph* in the lungs *to account for all the change.* Likewise in any point of inflammation there is an increased blood-supply. The tissues may be soaked with serum and infiltrated with leucocytes. The air-cells even may be filled with exudate, and thus the density of a part is increased and its transparency to X-rays decreased.

" Between *percussion* and the fluoroscope the comparison is more satisfactory. The same factors which determine the X-ray shadows also determine the character of the percussion-note. The results of percussion and skiascopy must agree, allowing for the personal equation and for the superior delicacy of one or the other in different hands. In my experience they *do* agree, except that skiascopy is the more delicate and more precise method. We may express the relation of percussion of X-ray shadows by adding a diagram.



This figure aims to convey an idea of the comparative relations between X-ray shadings and sound-notes. The internal conditions producing both evidences to the eye and ear can be best pictured to the mind after the study of shadow-values as taught in this work.

" The field of *auscultation* is larger in some directions than that of pulmonary skiascopy. Affections of the bronchial tubes denoted by *râles,* and inflammation of the pleura denoted by friction-sounds, are beyond the province of the X-rays. Auscultation is a most delicate method of examining the thorax, and the data which may be elicited are numerous. But their interpretation is often a matter of confusion or doubt even to a professor. Changes in the vesicular breathing; bronchial breathing; amphoric breathing; broncho-vesicular breathing; râles, large, small, dry, moist, sonorous, sibilant, crepitant, sub-crepitant, mucous, or bubbling; friction-sounds; bell-tympany; succussion; metallic tinkling; bronchophony; pectoriloquy, egophony, Wintrich's change of sound; William's tracheal tone; Gerhardt's change of sound; Fredreich's change of sound; and Leitz's metamorphosing; all of these suggest the resources and difficulties of auscultation.

"Skiascopy *gives more simple and direct data.* The apparatus which generates the Roentgen rays may be complex, but there is nothing unduly complicated about shadows on the fluoroscope screen. The shadow of a bottle partly full of water gives more simple and more direct evidence of its existence and character than do the sounds which may be elicited from it. The margin for possible error is wider for the stethoscope than for the fluoroscope. But when the signs are correctly elicited, correctly recognized, and correctly interpreted, *the results of auscultation must agree with those of skiascopy.*

"Skiascopy is not compared with *inspection* because it is itself inspection. It is an extension of our facilities of sight. It is therefore *a part of the physical examination and not a method to supplant it.* Although it bears comparison with the combined results of palpation, percussion and auscultation, it should not be considered as a rival, but as an *ally.* By Roentgen's discovery *inspection* is now raised to the first rank of our diagnostic resources. We base a diagnosis not upon the results of one, but upon all the lines of physical examination. Auscultation is not alone relied upon. For the same reasons skiascopy *should be interpreted in conjunction with the physical signs and the clinical symptoms.*" (Crane.)

We will next study the pulmonary findings of the radiograph in a most valuable series of clinical tests of late date.

Determinative Tests.—Very instructive analytical tests were made by Walsham * to determine causes of pulmonary appearances in the radiograph and the relation of certain shadows to diagnosis. His observations were presented to the Congress on Tuberculosis, London, July 22 and 26, 1901, and are so valuable that every physician should read them. We therefore supply the essential text.

"Since Professor Roentgen made known his brilliant discovery, now some five years ago, I have been at work on the use of the X-rays in the diagnosis of pulmonary tuberculosis. I propose bringing be-

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fore you this morning very briefly some of the results attained. The questions I attempted to answer, if possible, were the following:

"1. Can X-rays show tubercle in the lung?

"2. If so, at what stage of their development?

"3. Can X-rays detect tubercle in the lung earlier than diagnostic methods already at our disposal?

"Now, obviously the first step to be taken in the attempt to answer the first question was to obtain a radiograph of the normal chest, to study its shadows, and endeavor to differentiate between the shadows cast by structures outside the thorax from those cast by its contained organs.

"The next step was to take a radiograph of an undoubted case of pulmonary tuberculosis and compare the one with the other.

"I will now, first of all, throw on the screen a picture of a normal chest. We see at once that the pulmonary image in health is quite transparent from apex to base, with the exception of a few ill-defined shadowy lines to the right of the heart shadow. These cardiac lines are seen (more or less pronounced) in all skiagrams of the healthy chest, and must therefore be considered normal. Now, on what do they depend? Are they cast by the lower division of the longer bronchi? I think not. If we look at a picture of a normal lung skiagraphed outside the chest we see that only the primary division of the bronchi are seen, and, in addition to this, these cardiac lines are too low to be caused by the bronchi.

"I have endeavored to clear up this point in the following way: A skiagram was taken of a dead body on the post-mortem table. I then removed the sternum, opened the pericardium, removed the heart, replaced the sternum and integuments, and took a second radiograph. The lines still appeared in the negative. I then opened the chest, removed the lungs, replaced the sternum and integuments, and again radiographed the body. The effect is shown you on the screen. You see that these cardiac lines still remain and are caused no doubt *by the junction of the pericardium with the pleuræ.* They are much more distinct in the dead body, of course, as they are not then in constant movement with the contraction and expansion of the heart as they are in a living person.

"The next point you will observe is that *the shadows of the scapulæ are absent.* Their shadows only complicate pulmonary examinations and are better removed. This can be done in the following way: *The patient lies in the prone position on the plate, the arms being extended and hanging over the end of the couch. In this position the scapulæ are turned edgewise, so to speak, and their shadows are removed from the skiagram.*

"The next shadow to call to your attention is one well shown in our next lantern-slide, and is usually seen in the more muscular subjects. It is, as you see, somewhat triangular in shape, and extends upward and outward toward the axillæ. When viewed in *stereoscopic radiographs* these shadows are seen to be *outside* the chest and are caused by the anterior axillary folds of muscle. They are only seen, I think, when the patient is radiographed in the prone position with extended arms, this position naturally rendering the axillary folds thicker.

"A word as to the *diaphragm:* it is not so much the *shadow* of the diaphragm in the negative that is important in pulmonary diagnosis as its *movements with respiration* as seen with the fluoroscope. Now, if the diaphragm be watched with the fluoroscope we see that it does *not*, as physiologists tell us, become flatter with inspiration. *Its curve is always maintained unaltered.* It plunges up and down piston-wise, and this brings us to a point of great importance in the diagnosis of pulmonary tubercle. *The movement of the diaphragm on the affected side is much less than on the non-affected or less affected side, and this when the disease is limited to one apex.* Why this should be so may be hard to explain, but the fact remains.

"I will now throw on the screen a picture of a case of pneumothorax, showing the depression of the diaphragm by the increased pressure in the pleural cavity. If you will look again for a moment at the picture now on the screen you will see that the healthy chest in the living person is as clear as that of the dead body with the thoracic viscera removed, showing *that any abnormal shadow* seen in the skiagram *is due to some pulmonary change*, the muscles and integuments of the thorax being transparent to the rays.

"There is one other shadow I will mention. We occasionally see an ill-defined curved shadow in women with large mammary glands. Here the stereoscopic method again shows these shadows to be outside the thorax and therefore not to be confused with shadows produced by pathological changes in the lungs.

"I will now throw on the screen a well-developed case of pulmonary tuberculosis. You see at once there is a marked difference. The clear pulmonary image is obscured by flocculent shadow, punctate in parts. Now on what do these shadows depend? Are they due to tubercular consolidation or to patches of congestion of caseation or pleural adhesions or what? I have endeavored to answer these questions in the following way. On the screen before you is the skiagram of a tuberculous lung; nearly the whole of the upper lobe was caseous and breaking down. So we see that caseation throws a very dense shadow. The shadow, lower down, caused by gray and yellow tubercle, is nothing like so dense; still, as it might be said that some of this shadow is due to blood congestion round the tubercular consolidation, I performed the following experiment: The lungs from a case of pulmonary tuberculosis were taken; one was soaked in water for some hours to break up the blood-corpuscles, the vessels washed out until the water came away colorless. Both lungs were then skiagraphed, and I think you will agree with me that there is little or no difference between them.

"Again, it has been asserted that the blood next to the bones is

PLATE 145.—This Instruction Plate shows the Author's Examining Frame turned sideways and adjusted to an inspection of the chest, either back or front positions being equally engaged in the axis of the rays, which the frame holds fixed while the patient is shifted to bring successive fields and areas into the constant line of non-distortion. Letters A A in the intersecting angle of front and rear markers indicate the axis of the rays from the anode to the fluoroscopic screen. Simply level the frame, insert the patient, clamp on the screen and light up the tube and inspect the parts as taught. The photograph shows the patient's right arm thrown over the frame to get the shadow of the scapula out of the way, and the operator just ready to place the fluoroscope and begin the examination. The position of the camera failed to show the anode focus in exact line with the A A of the markers, but the plate suffices to teach the method.

PLATE 146.—Measuring Pulmonary Shadows by the Skiameter. Frontal position. Level the tube, hold the skiameter in the right hand against the back with the screen in front as shown in the Instruction Plate. The text makes the method clear. This plate also shows the tube in a "closet" holder which shuts when not in use and protects the tube from dust and breakage. In the corner is also a mounted open screen of large size, which is employed as taught in the next plate.

PLATE 147.—Measuring Pulmonary Shadows by the Skiameter. Dorsal position. Hold the Skiameter over successive areas of the chest while observing the shadows from behind with a large mounted open screen instead of the fluoroscope. Cut does not show the light-screen to hide the tube or the use of the cloth which may be thrown over the head and around the field of examination to create a dark chamber for the eyes. Both plates teaching the use of the Skiameter were photographed especially for this work by Dr. A. W. Crane, of Kalamazoo.

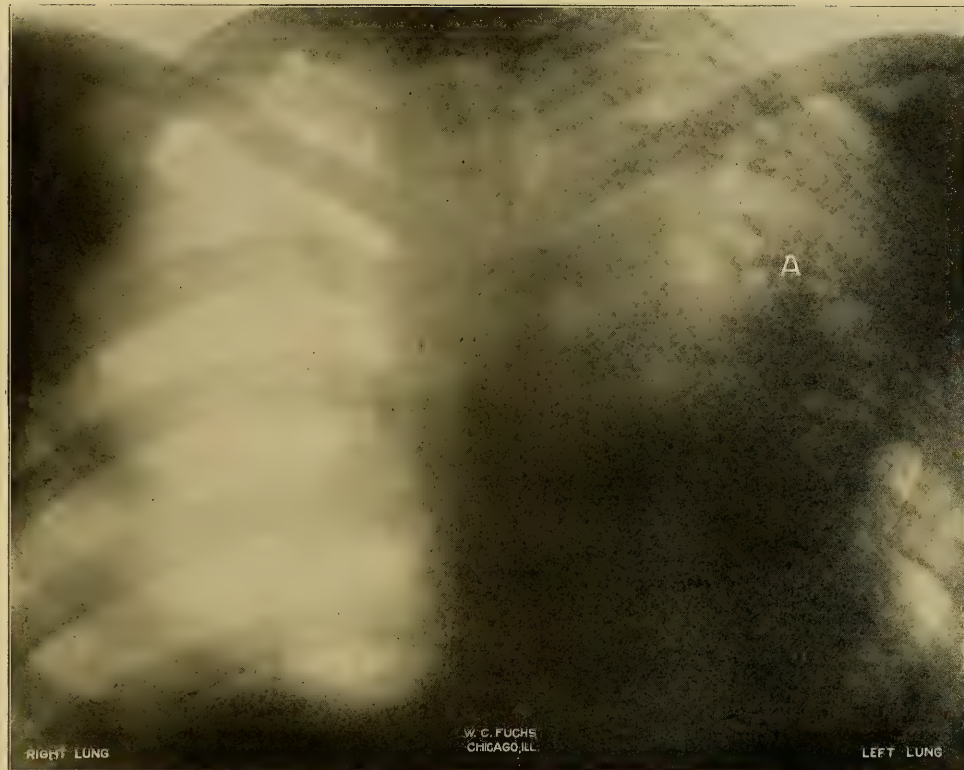


PLATE 148.—Tuberculosis of left lung showing darkened areas. Heart shadow undefined. Normal transparency of right lung shows it free from disease at time of radiographing the case. Examine this plate with mirror to reverse the picture.

the most opaque tissue of the body. With this assertion I cannot agree. Look, for instance, at the picture now on the screen. It represents a portion of a rib, a piece of muscle the same size, and a blood-clot. My eye can detect no difference between the muscle and the blood-clot—that is to say, clotted blood, which, by the bye, is more opaque than fluid blood, is no more opaque to the rays than muscle. Again I took the lung and kidney which contained tubercle from the same case, and radiographed them together. The tubercle in the kidneys is distinctly seen, down to the minutest miliary tubercle which could be detected by the naked eye. Again, look at these lungs from a case of acute miliary tuberculosis. They show the tubercle scattered through their substance clearly enough. Putting the above facts together, we may, I think, answer our first question by saying that the Roentgen rays *can show definitely tubercle in the lung.*

"I will now throw rapidly on the screen some cases of undoubted pulmonary tuberculosis more or less advanced. I now come to the question of the detection of cavities in the lung. That the X-rays can *detect with certainty a cavity in the lung* is now *a fact beyond question.* With reference to the size of a cavity, I would say that the rays *can diagnose a cavity much smaller than can be detected by auscultation.* The smallest I have yet met with is now on the screen before you. It is less than a small marble. The Roentgen rays are also of great use in judging the size of a cavity. Occasionally auscultation gives evidence of a cavity of large size, and we are surprised, on examining with X-rays, to find that the cavity is a small one. This must mean that the consolidation round a cavity must conduct the sounds produced in the cavity far beyond its limits. Furthermore, it not infrequently happens that auscultation diagnoses a cavity which the rays show has no existence.

"I will now pass on to the second question, viz., At what stage of development can the X-rays detect tubercle; and here I am afraid we must admit that the very earliest stage in the development of the tuberculous process cannot be detected by the X-rays, but this also applies to all our other methods of physical diagnosis. The first beginning of tubercle in the lung cannot be detected by this or by any other means at our disposal. There can be no doubt that the X-rays are able to pick out in shadow *a very small* tuberculous focus in the lung. I will give a few examples. The skiagram on the screen is from the chest of a man aged twenty-eight; he came to the out-patient room complaining of his digestion. On examining the chest there was nothing to be made out except perhaps a little weakening of the breath-sounds at the right apex. I examined this patient radiographically, and had no difficulty, as you see, in diagnosing a tuberculous process at the right apex. The next case is that of a woman aged thirty-four. In this instance there was a little prolongation of expiration, with some slight difference in the percussion note at the right apex. I was somewhat surprised, therefore, to find that there was extensive disease in the right upper lobe. The shrinking of this side of the chest is well shown, which was not detected on physical examination. The next two pictures are both from patients in whom pulmonary trouble was suspected, but which gave no evidence of its presence on stethoscope examination. The shadows, however, in each case are distinct, and later in their history the physical signs with the stethoscope became undoubted. I think, therefore, we are justified in saying that the X-rays *are able to diagnose really early tuberculous change in the lung.* I think, also, that the Roentgen rays can detect tubercle certainly as early as the stethoscope, or even earlier, as the last two cases show. Now it may be asked how can you tell a tuberculous shadow from that of a new growth. This can be done only by the distribution of the shadow and by the history of the case. As with the stethoscope, we have to consider the history of the individual case before us, so with the X-rays. Pray do not think for one minute that the X-rays can diagnose tubercle off-hand; such, I am sure, is not the case. But I think that this means of detecting an early tuberculous shadow brings a little nearer the day when internal tubercle may perhaps be treated with chemical rays, as external tubercle—viz., lupus—is being treated to-day with such conspicuous success. In the future we may perhaps be able to say of pulmonary tubercle: 'It comes as a shadow, so departs.'

"All the skiagrams I have had the honor to show you were taken with a coil giving a fourteen-inch spark between the terminals of the secondary coil. One word more and I have finished. I think in all cases of suspected pulmonary tubercle a skiagram should be taken. From an experience of over five years I am sure that a shadow can be detected on the photographic plate that would be missed on the screen."

That the student may better appreciate the informing value of fully edited text in an important paper of this kind we present as a typical contrast a so-called "abstract" from a leading medical journal in this country. Consider what instruction could be gathered from it. Yet it is a fair sample of what is supplied subscribers in this now popular method of conducting our high-class medical journals, so far as X-rays, electricity, and related subjects are concerned.

"At another meeting of this section the use of the Roentgen Rays in Diagnosis of Pulmonary Tuberculosis was discussed by Dr. Hugh Walsham and others. Varying degrees of success were reported, and hopes are entertained of more perfect results in diagnosis, and possibly some aid in treatment."

It is doubtful if less practical value could be put into the same number of words.

Studies in the Alphabet of X-Ray Readings.—" In any series of pulmonary cases examined by X-rays it will be seen that the *differential diagnosis lies between different physical conditions* rather than between different diseases. In only a few such cases as diaphragmatic hernia, or aortic aneurism can we make a *direct* diagnosis. If we find a shadow at the base of the lung, the question which arises is whether or not it is an effusion or a consolidation of the lower lobe, rather than whether or not it is tuberculosis or pneumonia; but it is one function of the X-ray examination to estimate the extent, form, and location of the involvement. Upon these must rest the prognosis and the special indications for treatment.

" A *bright reflex* * indicates a large empty cavity or a large pneumothorax. If it is a cavity, the bright reflex may be centrally located and wholly surrounded by a dark or black shadow, or it may be peripherally located and only partly surrounded.

" The limits of a large cavity are never sharply marked unless on the lower side when partly filled with sputum. If it is a pneumothorax the bright reflex is peripherally located and usually larger than in the case of a cavity. If it exists without the presence of pulmonary shadows the diagnosis is clear, because a cavity is always associated with some consolidation. If, however, consolidation does occur with pneumothorax the *outline of the lung* will be observable. A local pneumothorax from bronchial communication with the pleural sac, and from circumscribing adhesions, could not be distinguished from a peripheral cavity, especially if it occurred over the front or back area. Its position, however, front or back, could be determined by noting from which side it could be most plainly seen, for *the closer any object lies to the fluoroscope the clearer is the image.*

" A *light reflex* indicates (1) a small cavity, (2) a large cavity nearly full, (3) a small pneumothorax, (4) a greatly dilated bronchus, (5) or emphysema. If it be a small cavity it will lie in the midst of a dark or black shadow, and may be called a ' light reflex ' because it is in contrast with its surroundings. It may be encircled by a narrow ring of dark or black shadow if the walls are calcified. This is a healing process that can occur in a small cavity only. The calcareous thickening of a spherical cavity casts the shadow of a ring because the X-rays traverse more substance in passing through the edges of the walls than in passing through the middle of it.

" If it be a large cavity nearly full, the *light reflex* will rest upon a dark or black circumscribed shadow, unless the surrounding consolidation is so dense as to obscure the shadows of the mass of

* **Definitions.**—In this section certain terms are employed by the author with the following significance:

Light Reflex. An illumination of the screen, such that the smallest hole in the single layer of the skiameter is distinguishable by the examiner's eye.

Bright Reflex. An illumination appreciably brighter than the light reflex, which always adjoins or surrounds it.

Light Shadow. Shadows ranging from one to two degrees on the skiameter scale.

Dark Shadow. A shadow denser than one degree and less than five degrees.

Black Shadow. Densities ranging from five degrees upward.

sputum. If the patient is re-examined on the table, the cavity may then empty and become a large bright reflex, or it may nearly disappear, because the mass of sputum has come to lie in line with the empty space.

"If a faint reflex be observed without the presence of pulmonary shadows, it is probably due to a dilated tube in bronchiectasis. A dilated bronchus with consolidation could not be distinguished from a small cavity, unless a longitudinal form were to give a clew. A small pneumothorax, allowing a layer of air to surround the lung, would give a general light reflex, which would be indistinguishable from a true emphysema. In both cases the movements of the diaphragm would be restricted, its line low, and its form flattened. But an emphysema is bilateral, unless there is some disease of one side to produce a compensatory condition on the other. In the case of pneumothorax, the disease would be on the same side as the general light reflex. Hydropneumothorax or pyopneumothorax would give the same images as pneumothorax, except that we would have the dense shadows of effusions at the base. By changing the position of the patient, the relative position of the shadows and light reflexes would be changed. A light shadow may mean an infiltration, a congestion, and atelectasis, or a thickened pleura. Between a tuberculous infiltration, a simple focus of congestion and an atelectatic area, there is no shadow distinction. A thickening of the pleura may sometimes be differentiated from these three if the shadow be plainly visible, say from the front, and nearly or quite invisible from the back. But an infiltration or small infiltration laying close to one side would simulate this appearance. A dark shadow indicates a partial consolidation—a small tumor, an infarction, or a cirrhosis. In the case of œdema the dark shadow is general and has an even density. A general cirrhotic lung would give a less even shadow, and would be accompanied by a marked displacement of the heart. Other physical conditions easily differentiate these two.

"A focal cirrhosis and infarction and a small tumor, may give shadows of similar character, but a cirrhotic focus is most likely to be located in the apex, a tumor most likely near the hilum, and an infarction most likely in the periphery. A partial consolidation has very indefinite borders shading out into normal lung-tissue. A small filled cavity is associated with some consolidation, and will appear as a dark spot in the midst of the dark shadow.

"A black shadow may result from a consolidation, gangrene, large filled abscesses or cavities, large tumors, large hydatid cysts, and pleuritic effusion. The last is distinguished by lying at the base of the thoracic cavity, by obscuring the diaphragm line, by a more or less level upper border, and by being shifted when the patient's position is changed. The other conditions may not be separable by an X-ray examination, but their boundaries may be mapped out.

"The diaphragm cannot be disregarded in fluoroscopy of the lungs. Its visibility, position, form, and motion are functions of the highest importance in estimating the extent and severity of pulmonary disability. It is the vital barometer of the lung, and they here give the first signs of coming clouds above. Its visibility depends upon the contrast which its heavy shadow makes with the thin shadow of the lung. It is a dome of muscle which rests upon the liver on the right, and is visible across the whole extent. On the left it rests upon the stomach and is visible across the outer half of the heart, the inner half being obstructed by the shadow of the heart. In forced *in*spiration, however, the diaphragm becomes also visible below the heart. The pericardial space between the heart and the diaphragm is formed in forced *in*spiration when the diaphragm pulls down the pericardial sac while the attachment at the base holds up the heart. The presence of the *pericardial space* may be taken as a positive sign that *no pericardial effusion exists.*

"The shadow line of the diaphragm becomes more distinct in forced *in*spiration because the lungs contain more air, and because the diaphragm, being flatter, interposes more tissue in the path of the rays. Conversely, the diaphragm lines become less distinct in forced *ex*piration because the lungs contain less air, and also because the diaphragmatic dome, being more arched, interposes less tissues in the path of the rays. The diaphragm becomes very distinct when there is an emphysema or pneumothorax without effusion. But emphysema is either bilateral or else compensatory, and attended by disease on the opposite side. On the other hand, pneumothorax would show the shadows of a partially or wholly collapsed lung. The diaphragm may become indistinct in œdema, hypostatic congestion, partial consolidation of the lower lobes, or thickened pleura around the base. But in œdema there is a general shadow of an even density. In congestion, partial consolidation and thickened pleura at the base, the upper areas of the lung may be normal, but these three are not separable on physical grounds alone.

"The diaphragm becomes invisible when there is an effusion or a consolidation of the lower lobe. But with effusion the outline of the shadow may be easily shifted, and when the patient is put upon the examining table with the head and trunk tilted downward the diaphragm comes into view. If the entire lung is consolidated, or if the effusion reaches the apex, the conditions may not be distinguishable without the use of the hypodermic needle. The position of the diaphragm in health is variable. The mean in ordinary respiration is, for the right side, the lower border of the fifth rib; for the left side, the upper border of the sixth rib. *The left side is normally about one and one-half centimetres lower than the right.* In disease of one side this difference is exaggerated.

"If the right lung is affected by tuberculosis, the diaphragm on that side will be higher than usual, while on the left it will be lower than usual, on account of the compensatory changes. In emphysema the diaphragm lies very low, in cirrhosis very high. The position of the diaphragm largely determines the form. It is flattened when low, and arched when high. In diaphragmatic hernia the form is irregular.

"It is the *motion* of the diaphragm with which we are chiefly concerned. We may recognize the range of movement in ordinary and in forced respiration. By marking the middle point in ordinary respiration, we may observe the upper and the lower half of a forced respiration. As a rule, in health the range of ordinary and forced respiration is slightly greater on the right side than on the left. *A restriction in the range of motion is a sign of some disablement.* It is most likely to mean tuberculosis, pneumonia, or pleurisy. But it may mean almost any affection of the lungs or mediastinum.

"In true emphysema and pneumothorax the respiratory movement is restricted in its upper half. In compensatory emphysema the respiratory movement is increased in both upper and lower half. This is important, because a compensatory emphysema on one side means an impairment of the lung on the opposite side. It may, however, in rare cases, be an old trouble from which the patient has recovered. A very marked restriction in the motion of the diaphragm or its immobilization is a grave sign. Pleurisy, especially diaphragmatic pleurisy, forms an apparent exception. However, if the patient be encouraged, the diaphragm can be moved, although pain is the result. It is a significant fact that nature so quickly *immobilizes a diseased lung.*

"*When in addition to the shadow-free lung, we find a natural movement of the diaphragm, we may feel assured that, even though tubercle-bacilli are present in the sputum, the lung is not yet affected. Such cases may be laryngeal or bronchial.*" (Crane.)

Diagnosis of Pulmonary Tuberculosis.—The report presented by Bouchard and Claude to the Congress on Tuberculosis held in Paris is remarkably instructive.

"In this disease *at the outset* the lesions consist of new formations which constitute an obstacle to the penetration of air and a slight obstacle to the penetration of X-rays. At this stage the fluorescent screen will show at one apex, or both (sometimes at several places in the lungs), small spots, ill-defined at their circumference, or a slight mistiness veiling one apex. In other cases the appearance resembles a stippling of small shadows on a less dark ground. *Confluent pulmonary infiltrations* with a tendency to softening and ulceration give rise to almost complete opacity. These are darker in the case of lobar infiltrations, and lighter in the case of lobular infiltrations.

"*The intensity of the shadows is proportional to the interference with the penetration of air into the vesicles.* If the lesion forms a compact and considerable mass absolutely impenetrable by air the shadow shown on the screen is complete, but if there are a number of little nodules separated by parts still permeable by air, the general opacity is less intense, and on the dark ground there will be seen still deeper shadows corresponding to points of complete caseation.

"*Cavities* appear on the screen as a *complete* opacity only (1) if they are filled with pus, or (2) if deeply seated and surrounded by pulmonary tissue stuffed with tubercle; or (3) when a layer of dense adhesions obstructs the passage of the rays. If the cavity is superficial, *empty*, and has a thin wall, it shows as a clear zone in contrast with surrounding parts of the lung which appear more deeply shaded. It is oval in shape, and the ribs in front of it are visible. When the cavity *fills up*, the clearness which marks its situation diminishes, and we see only a large shadow, rather less dense at one part than throughout its general extent.

"Every degree of variation is possible, but *the essential character in all forms of the shadow-picture of cavities is the presence of a very dark zone more or less circular in outline, surrounding a region relatively clear or altogether transparent, while the rest of the lung adjacent is in shadow.* It is the sharp contrast between these two elements of lesion-spots relatively clear *showing on a ground palpably dark*—a shadow *shading off at the circumference,* and *sharply defined around the central clear zone*—that is characteristic of a cavity.

"The *pneumonic confluent form of acute phthisis* reveals itself on the fluoroscope by complete opacity of the diseased part. This is explained by the fact that at these points the lung is no longer pervious to air.

"*Effusion at the base* is shown by a thick shadow which hides the diaphragm, and is lost below in the obscurity of the abdominal mass, and is limited above; a zone of shadow directed obliquely from above down from the axillary region to the vertebral column, or in the shape of a curve which is concave at the upper border. Examination at intervals of a few days will show the variations in the amount of effusion by variations in the extent and form of the shadow.

"An intense opacity with a generally rounded outline occupying the middle part of a lung, in which the upper and lower parts have retained almost their normal clearness, suggests an interlobar effusion. Here, again, the *variability of the shadows at different times* assists the diagnosis.

"Dense and extensive *adhesions of the pleura* manifest themselves by shadows which are less dark, but constant in their form. In such a case it is often impossible to distinguish the condition of parenchymatous lesions by fluoroscopic examination alone.

"*Pneumothorax* is characterized by an abnormal *transparency* of one side of the chest, which allows the light to pass through without any interference except over a small area on the affected side corresponding to the retracted lung. The heart and the vessels may be displaced. The curve of the diaphragm is lower than in health.

"In *hydropneumothorax* and *pyopneumothorax* the appearances *vary according to the position of the patient.* If he is lying down the whole of the affected side is dark. If he is standing up, the upper part of the side is more transparent than in the normal state, and the lower is opaque.

"Even slight tuberculous changes in the pleura affect the mobility of the *diaphragm*. In general terms it may be said that *in pulmonary tuberculosis there is a diminution in the movements of ascent and descent of the diaphragm*. This change may be seen on one or both sides. The fluoroscope can also give important information as to the condition of the mediastinal glands in tuberculous patients.

"In acute or sub-acute *bronchitis*, the two sides of the chest show little or no departure from the normal state, and there is no change in the respiratory movements of the diaphragm-*negative signs* which may often be of importance in prognosis.

"In *pneumonia* there is complete opacity at the part corresponding to the lesion. This opacity, however, varies in its limits and intensity from day to day. The movements of the diaphragm are diminished on the affected side.

"*Non-tuberculous* broncho-pneumonic foci cause a slight opacity, but this becomes *less marked* on deep inspiration, while foci of pulmonary *sclerosis* do *not* become clearer on deep inspiration.

"In simple *emphysema* the *transparency is increased* by the increase of air present, and the ribs are less distinct.

"The emphysematous lung is larger than normal and extends into the pleural cul-de-sacs, so that the transparent surface corresponding to the organ extends more upward toward the mediastinum, and particularly more downward toward the abdomen. When the patient is examined at the back there is seen below the diaphragm a transparent surface of much greater extent than normal.

"*The use of the X-rays makes it possible in certain cases to discover commencing changes in the lungs at a period when other methods of clinical investigation are negative.* In other cases the fluoroscope *defines the extent* or *reveals the importance* of a lesion insufficiently disclosed by auscultation or percussion. It enables the practitioner to *exclude tuberculosis* in cases where symptoms and clinical signs puzzle the physician; while at the same time it often *enables him to trace to their true cause general disturbances which clinical observation has failed to locate.*

"Fluoroscopic examination *is not merely the method of control*, correcting or supplementing the ordinary methods, but *it yields new information*. By making visible the working of the respiratory apparatus it shows the functional value of one lung. It discloses the pleural adhesions, the pareses or ankyloses of the diaphragm, which limit expansion: *it makes the evolution of the disease visible to the eye*."

In the report of Beclère before the Paris Congress on Tuberculosis the author held that for exact and complete diagnosis of tuberculosis lesions the examination should include a radiograph as well as the fluoroscope. He described *X-ray diagnosis* in *latent, suspected,* and *declared* tuberculosis.

"In latent tuberculosis the patient has every appearance of perfect health and presents absolutely no physical sign or symptom of disease. The frequency of this condition is shown by the large number of soldiers who have died of various diseases in whom old unsuspected tuberculous foci have been found. In a series of experiments 124 men were examined, selected from among those in whom ordinary diagnostic methods excluded tuberculosis. Seventy-three of these cases gave negative results with the fluoroscope, but the remaining fifty-one revealed abnormalities of various kinds—lessened transparency of apices, enlargement of the bronchial glands, more or less marked opacity of the pleura, diminished movement of the diaphragm.

"The use of the X-rays also serves for the identification of tuberculous lesions which disguise themselves under the mask of anæmia, chlorosis, dyspepsia, and neurasthenia.

"In cases of suspected tuberculosis, if the disease attack the lungs suddenly, the fluoroscope shows chiefly a diminution in the clearness of the shadow at the apex, and pushing down of the diaphragm on the affected side. Tuberculosis may begin with an attack of diaphragmatic pleurisy, the symptoms of which are so slight that the only proof that the pleura is involved and that the case is not merely one of intercostal neuralgia is supplied by the X-rays, which show thickening, diffusion, and immobility of the diaphragmatic shadow. If the case is one of dry pleurisy, or 'stitch' in the side, but without any decisive physical sign, the fluoroscope shows superficial opacities quite close to the thoracic wall. In cases of effusion the condition of the apex in regard to transparency on the affected side must be carefully investigated. *Even a slight degree of opacity in the region of the apex is important in prognosis.* In declared tuberculosis the lesions are plainly shadowed on the screen. In such cases the X-rays are more valuable for prognosis than for diagnosis, since the diagnosis is already made. They will show when both apices are attacked, when ordinary clinical examination appears to warrant the conclusion that one is still sound, or when the lesions extend lower down than is disclosed by ordinary methods. X-rays are particularly useful for the detection of central lesions, which are apt to be overlooked on account of the depth at which they are situated."

Detection of First Stage of Consumption.—In discussing the question of an earlier diagnosis of tubercular disease of the lung by X-rays than by clinical methods, Immelmann states:

"To answer the question at the head of this paper we will consider at what stage of lung disease it has been possible to give an undisputed diagnosis with the methods in use hitherto. We cannot rely upon *percussion;* its results are often in no proportion to the gravity of the disease. It may not give any indication in very early stages of the malady, nor even of small cavities imbedded in the air-holding tissues of the lungs. With *auscultation* it is not very different. No sound of respiration is *characteristic* of the phthisical process. We are in a position to give a definite diagnosis *by clinical methods* only *when* the tuberculous foci of disease disintegrate and open into the bronchi, and the possibility is offered of finding tubercle bacilli in the sputum. I have carried out the following experiments as clinical tests:

"1. Having examined eleven patients with the screen in whose sputum bacilli have been observed for the first time shortly before, in all of them I was able to decide that infiltration and disease-foci of the lungs showed as dark places in the air-containing lung-tissues.

"2. In eight patients suffering from lung catarrh but having no bacilli in the sputum, I observed that the apices of the lungs appeared less transparent than the normal. After three or four months four of these have bacilli in the sputum.

"3. Of seventeen patients also suffering from lung catarrh, but whose lungs appeared normal, thirteen are not quite healthy after three or four months, while in the four others the apices have become opaque.

"When the X-rays find *the transparency of the apices of the lungs reduced;* when we see *that they do not take full share in the breathing*, or are *so shrunken that they are no longer seen above the collar-bone;* and when we remember in addition that consumption generally begins in the upper third of the lungs, we shall then *with probable certainty decide on a diagnosis of phthisis in an early stage.* And we shall do this still more certainly if we find further corroborating signs in the physical examination that we next make.

"I may also state that in some suspected patients I have first fixed the seat of disease by the rays, and have then been able to prove by percussion and auscultation changes which I had previously sought for in vain before the examination with the rays. *Further,* I will suggest the possibility of observing an appearance directly with the eye which is characteristic of phthisis—I mean *the smallness of the heart.*

"Naturally, it will not be possible to make a successful diagnosis of every case by the aid of the rays. Mistakes are possible, but practice improves the diagnostician. As to the diagnosis of advanced tuberculous patches, as well as of cavities, whether superficial or deep-seated, I will state that the former give dark shadows, the latter show light patches, clearer even than the surrounding lung-tissue.

"The fluoroscope is of immense importance in estimating the prognosis in pulmonary disease. When the treatment can be begun at a time when the screen shows that changes have only just set in at the apices a perfect cure may be expected, and in advanced cases X-rays will decide whether the patient has still a chance of relief."

In other sections of this System of Instruction readers will be taught methods of treating tuberculosis which seem to promise much better results than methods in common use. With effectiveness they combine great simplicity.

Diagnosis of Pus.—With reference to the possibility of demonstrating collections of pus in the lungs, the following report of a surgeon is of interest:

"I will now pass around a skiagraph which was taken to-day of the chest of an old man, fifty-five years of age, who gave a history which resembled very much that of a pneumonia, dating eight weeks before his admission to the hospital. Some four or five weeks after the onset of the pneumonia he coughed up a large amount of pus; according to his description it must have been a pint. He continued to have fever, to lose in weight and strength. A skiagraph was taken to see whether or not it would locate the pus, and while waiting for the skiagraph a needle was inserted at the point which I have marked on the skiagraph, and pus was found there. On close study of the skiagraph it will be seen that just under the left scapula and extending downward toward the median line there is outlined a shadow which corresponds quite accurately to the dulness mapped out, and from which point we withdrew the pus. Comparing the two sides, it will be seen that about the angle of the right scapula and in the intervertebral space there is far less shadow than on the corresponding point on the left side.

"The ability of the X-ray at times to locate pus in the chest was clearly shown in a case seen with Dr. ———. My doubts as to the existence of pus and my somewhat sceptical view that the shadow and the physical signs might be due to adhesions and thickenings, were removed by operation and evacuation of about eight ounces of pus." (HERRICK.)

Function of Repeated Examinations.—Reports of many cases showing the importance of repeating X-ray examinations at judicious intervals of time have been made by wise observers. The need of this is greatest in medical diagnoses of parts other than bones. A number of temporary conditions related to the heart, circulation, and state of the patient, seem to darken a part or whole of the lungs. If seen at a first examination it can readily be determined whether the lungs are affected by subsequent inspections four or five days apart. The darkened area will clear if the process was acute or secondary, while if chronic or a primary disease of the lungs the shadows will not be cleared by relief of another supposed cause. A doubtful case carefully watched for a month will reveal itself very clearly by this method. In a similar way the heart may be watched either for the progress of dilatation, or to exclude cardiac disease, or to observe changes during treatment, or the alterations between quiet and active exercise.

Many things that are reported as visible to the eye with X-rays are only so after careful, efficient, and repeated observations, made with systematic intervals and a regulated control of the conditions most favorable to the view. Do not forget that many of the achievements of the miscroscope are triumphs over difficulties, and the most brilliant work of the X-ray is done by conquering whatever difficulties sundry patients present. Fine work is not a careless offhand glance and snap diagnosis, but the result of painstaking sifting of all the facts that can be gathered by all methods of examination and interpreting them for the given case.

Those who may have erroneous ideas as to the place of X-rays in pulmonary diagnosis can set themselves right in a few lines:

1. In suspected tuberculosis (or often in cases not yet suspected) an efficient examination with X-rays by fluoroscope and radiograph is capable of determining whether the disease has or has not yet begun with greater certainty than any other method at the same date. Physical signs are absent.

2. In the early stage when physical examination can detect signs of the disease the fluoroscope confirms the diagnosis and marks out the extent of tissue affected. This service is not without value.

3. In later stages there are so many ways of making the mere diagnosis that the function of X-rays is different. Efficient X-ray examinations can watch the progress of the disease with great accuracy, reveal the extent of tissue invaded, locate the worst areas, detect or exclude certain advanced lesions, and an operator skilled in localization can many times point out where to enter the thorax for the removal of pus, etc.

Closer study of all that X-rays can do in skilled hands would surprise men whose custom it has been to over-estimate auscultation and percussion; methods which leave more to the imagination than most non-experts admit or suspect. In fact, the great part played by the imagination in physical diagnosis was not revealed till the X-ray demonstrated it. But every difficult diagnosis must be a composite process in which the X-ray takes only its legitimate part.

Diagnosis of Diseases of the Heart and Aorta.—It is but a short step from the lungs to the heart in X-ray examinations. The technic of one merges with the technic of the other. The interests of the two are so nearly mutual that no practitioner looking at the lungs will venture to pass by the heart.

The best view of the *heart* is obtained by *anterior inspection*, and particularly *at the end of a deep inspiration* when the shadow of the heart is more or less completely separated from the diaphragm. In a thin subject the nearness of the heart to the screen creates a sharply defined shadow of the organs. In a thick subject the greater distance of the heart away from the screen causes a loss of definition, and blurring of the outline and the shadow is larger than the organ. When necessary to do so the patient may be placed at a greater distance from the tube (twenty to thirty inches) to avoid enlargement of the shadow.

It has been found that the part of the heart-shadow which shows the greatest amplitude of movement is at about the middle of its left border, where it crosses the shadow of the fourth rib. The first sound of the heart is exactly synchronous with the end of the movement of the left border toward the left. This lateral movement is therefore pre-systolic and corresponds to the period of auricular systole. By means of the fluoroscope it is clearly demonstrable that the so-called apex-beat as noted by external palpation does not in all cases correspond with the position of the apex of the heart. Change of position from the right lateral recumbent to an upright position, and thence to a left lateral, causes a change in the position of the heart amounting to nearly three-quarters of an inch. When the arch of the aorta is the object of inspection the right anterior oblique position of the patient is most favorable.

"If the size of the heart is abnormal we have an indication of disease either inside or outside of the heart. If size is normal it is not probable that any serious chronic valvular lesion is present in a young patient. The recognition of an enlarged heart being important a very large number of tests have been made by experts to determine the relative accuracy and completeness with which the outline of the heart may be mapped by percussion and by competent X-ray apparatus. The *verdict* is not only *very greatly in favor of the X-ray as an instrument of precision, but its obvious superiority needs no argument in the majority of cases.* It is also important to have a means of discovering whether the heart is abnormally *small* in proportion to the demands of the body, and an X-ray examination is incomparably beyond any other method for this purpose.

"Errors of percussion are less frequent in normal cases, but they are relatively frequent and difficult to avoid in departures from the normal size of moderate extent. Moreover, while the degree of expertness in percussion which would enable a physician to lay claim to almost unfailing accuracy in his ability to outline the heart must always be the rare possession of a few extremely gifted and highly trained men, yet the humblest physician possessed of sight may see the shadow of the heart on the screen. With the aid of the screen accurate tracings * may be made which show not only the size and position of the organ, but the range of its movements. These tracings can be made in less time than would be spent in percussion. Each border of the heart can be separately examined with the shadow but little magnified and practically free from distortion. It is only necessary to put the patient in the right position in relation to the tube and screen and regulate the degree of radiance. Percussion may give excellent indications of what lies near the inner side of the chest-wall while the X-ray reveals the entire width and length of the heart. The best view of the heart is obtained during full *in*spiration when the intercostal spaces are increased and the descent of the diaphragm makes the axis of the heart more vertical than during expiration.

"When the lungs are transparent and the patient not too muscular the X-ray enables the outlines of the ventricles to be made out more accurately than by percussion. Another advantage of great importance is that a displaced part is not mistaken for an enlarged one. If the heart is increased in size it can be ascertained whether the right or left ventricles are enlarged. In favorable subjects enlargement of the auricles, more especially that of the right side, can be distinguished. These diagnostic possibilities of the X-ray are of particular value in the early stages of cardiac enlargement when so much more benefit can be hoped from treatment than in later stages of disease."

Exact directions for cardiac exposures, both for fluoroscopic and radiographic examinations, are taught in Chapter XV. on Selected Operative Technics. Those especially interested in measuring the size and outlines of the organ may refer to description of the author's heart-shadow outliner in Chapter XI.

Study of the "Heart-Reflex" with X-Rays.—"What I have referred to as the *heart-reflex* pertains to a curious phenomenon which is only manifest by means of the X-rays and the fluoroscope. It is a contraction of the myocardium reflexly induced by irritation of the skin in the precordial region. The illumination of the thorax by aid of the X-rays furnishes us with a comprehensive view of the *situs viscerum thoracis in vivo*, together with the functional phenomena of the viscera. The movements of the heart are first manifest in the left ventricle, beginning at a point about two centimetres from the apex of the organ. The active changes observed have been likened to the opening and closing of a lid and vary in frequency and extent. In some instances, the change in form is manifested by rapidly recurring light and dark shadows. A change in the position of the apex is only rarely observed. At times one may note the isolated contractions of the muscles and ventricles and even recognize the time interval between the contractions. A change in the form of the right ventricle is rarely observed, although in some individuals it is very

* For directions see Chapter XI.

apparent. A little practice soon enables one to trace the outline of the heart on the chest-wall with *a dermograph in a metallic casing.* The entire outline of the heart may be determined from the *anterior* surface of the chest, whereas the heart-view from the *back* shows only a portion of the organ, owing to its position in front of the vertebral column and the oblique site of the organ in the thorax.

"The heart-reflex is best studied with the fluorescent screen approximating the *anterior* chest-wall. The reflex is especially pronounced in children, and is best seen in adults with thoraces scantily furnished with musculature and panniculus. If we irritate the skin of the thorax in the precordial region by vigorous rubbing with a blunt instrument, a contraction of the myocardium is observed. Myocardial contraction is, as a rule, more manifest in the left than in the right ventricle. The contraction thus induced reflexly is sudden and of momentary duration, and, like other reflex acts, soon becomes exhausted. The degree of myocardial recession varies greatly. In some persons it is scarcely perceptible, while in other individuals it may recede fully an inch on either side upon the first application of the cutaneous irritant. The ether-spray is unquestionably the best cutaneous irritant, but its use necessitates the employment of an assistant. Stimulation of the centre for the inhibitory nerves of the heart reflexly by centripetal nerves is an adequate explanation for the heart-reflex. It is a physiologic axiom that stimulation of the respiratory centre is greater through the cutaneous nerves than through the vagus branches to the respiratory organs.

"*In diagnosis, the heart-reflex may serve as an index to the condition of the myocardium. Observation has taught me that when the heart-muscle is healthy, the reflex is active and vigorous, while in degeneration of the muscle it is feeble or absent. In pericardial exudates and pericardial synechiæ it is likewise absent.*

"In the treatment of chronic heart-disease by balneotherapeutics, mechanotherapeutics (Schott treatment), I believe that the heart-reflex must be taken into account. I refer to the reduction in the area of heart dulness after the resistance-movements and the baths to cutaneous irritation, and think that the myocardium responds to the Schott treatment irrespective of any other factor beyond reflex-contraction of a muscle following peripheral stimulation of cutaneous sensory nerves. In many of my patients I employ vigorous cutaneous frictions, in lieu of the conventional Schott treatment, on account of its being simpler, more expeditious, and less expensive. The results have been nearly as good as with the Schott treatment. Relief of dyspnœa follows, and there is marked reduction of the pulse-rate, together with an increase in volume and force." (ABRAMS.)

In the author's volume on Static Electricity the reader will be instructed in methods of treatment which are deemed very much simpler and very much better for the patient than the classical method of Nauheim.

Chronic Pericarditis.—The X-rays may possibly help in the diagnosis of an adherent pericardium. Ordinarily the movements of the heart are well shown in different positions of the body. If the visceral and parietal layers of pericardium are adherent to themselves and to the chest-wall and pleura, the limitation of movement which might then be observed would be a factor in the diagnosis.

After pericarditis the heart is larger and the entire muscle casts a darker shadow than a normal organ. It is also stated that a rapid heart action permits a better outline in the radiograph than a slow beat, as the heart then occupies its marginal positions most frequently, and secures more effect of the exposure. Much of the clearness of the heart in a radiograph depends on the structure of the patient. A lean muscular subject is the ideal, largely because the heart then approaches nearest the film and casts a sharp shadow. A fat person blurs the heart-shadow on both screen and film, chiefly because the thick mass of tissues in front of the heart removes the organ so far back from the film that the effect of the crossing of the rays fogs the margins, and the increased distance between the heart and the front surface lessens the contrast. Remember that all the information obtainable by X-rays cannot be secured in every case. Some cases present difficulties that are wholly absent in others.

Slow Pulse.—Relative to the characteristics of slow pulse a unique observation is that of Auche and Martin, who examined, by means of the fluoroscope, a man subject to attacks of vertigo, who had habitually a pulse of about forty. They report "the cardiac contraction is brisk and does not last longer than ordinarily. Dilatation is rapid, but when it is accomplished the heart rests. During the whole of the long pause ('grand silence') it is impossible to determine the least contraction of auricles or ventricles. There is no abortive systole." Information of this kind could not be obtained without the aid of X-rays.

Aneurism.—In writing of the value of X-ray examinations in some of the less frequent diseases of the chest, Williams states that aneurisms of the thoracic aorta may be seen by the X-rays *before there are physical signs.* This method of examination may give us greater assurance of the absence of an aneurism of the aorta in suspected cases than any other evidence that we can have.

He reports the examination of thirty-four cases, fifteen having typical aneurisms, six had more or less dilatation of some portion of the arch, one showed an outline suggestive of aneurism, but there was no pulsation and on autopsy a mass of glands was found. The remainder gave normal outlines in the region where an aneurism had been suspected.

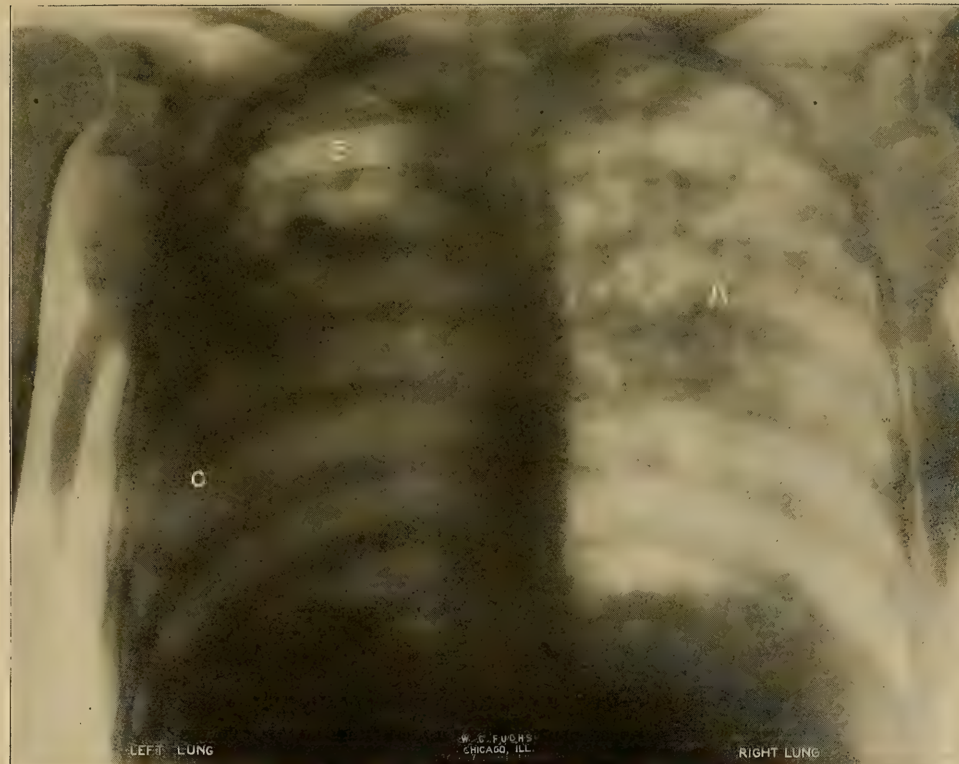


Plate 149.—Tuberculosis with cavity in left apex. "B" marks the cavity; "C" marks darkened area of extensively diseased lung of same side; "A" marks upper half of right lung with moderate consolidation and disease.

Plate 150.—Radiograph of case of pericarditis with effusion and showing tuberculosis of the right lung and the distended pericardial sac. To get normal view hold this cut in front of mirror with a good side-light. "A A" mark heart boundary; "B B" mark sac boundary. Clinical diagnosis agreed.

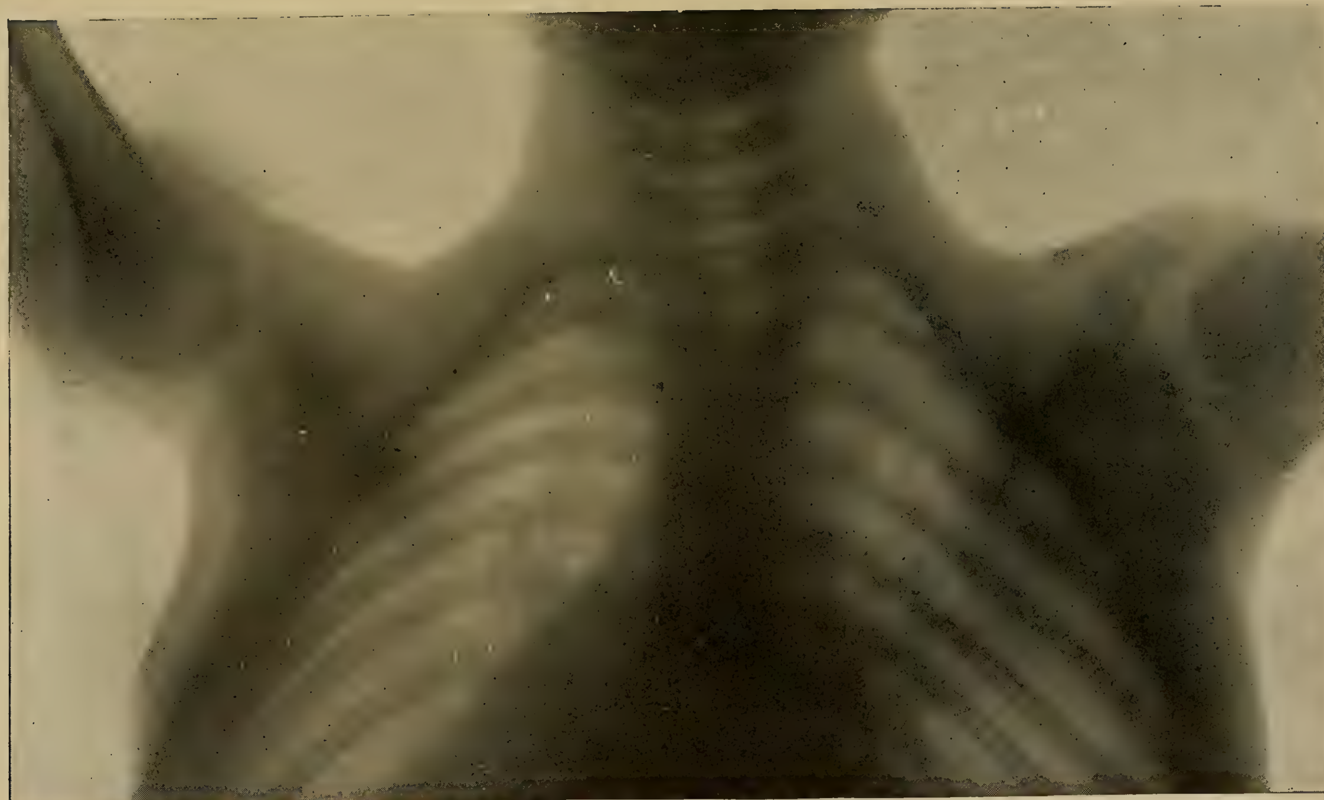


PLATE 151.—Congenital absence of the clavicles in a girl of fourteen. On one side a short portion of a clavicle can be seen, but the opposite bone appears to be entirely absent. The patient's shoulders can be brought together in front of the body. (Rebman, Ltd.)

In thirteen of the fifteen cases the aortic arch was the seat of the aneurism; in one of these there was a second aneurism in the innominate artery also; in the fourteenth case there were two aneurisms, one in the innominate and another in the subclavian artery; in the fifteenth case the aneurism was in the subclavian artery.

The physical examination of twelve out of fourteen of the cases of aortic aneurism was given in the hospital records; in five cases there were no physical signs of aneurism; in eight cases the heart was enlarged, and in five of these there were murmurs indicative of valvular defects, four of which were aortic and one mitral. Arterio-sclerosis was found in the three cases in which an autopsy was made. No nephritis was found in any case. *A transverse position of the heart* is believed to be an important diagnostic sign of intrathoracic aneurism.

In cases of aneurism X-ray examinations are of special value as an aid to prognosis, and their results tend to prove that the functional disturbances are sometimes in inverse rather than in direct proportion to the gravity of the lesion.

CHAPTER XXXV

THE FLUOROSCOPE IN PLEURITIC EFFUSIONS

Studies in the Examination of Clinical Cases.

In December, 1896, Professor Bouchard published observations with the fluoroscope and laid down the following dictum:

"*When opacity of great extent is not accompanied by displacement of the mediastinum it is more probably caused by pulmonary infiltration than by pleural effusion. Per contra if the opacity becomes gradually more pronounced from above downward, and if the heart is displaced, while the other side is transparent, there is probably effusion.*"

Within a year these diagnostic conclusions were confirmed by clinical reports of Bergonie, Beclère, Oudin, Barthelèmy, Williams, and others. In effusions of the left side the heart may be seen displaced to the right even when the displacement cannot be demonstrated by percussion. In the classical report of MM. Bergonie and Carriere, published * February, 1900, the investigators used a twelve-inch coil excited by twenty secondary cells controlled by a rheostat. The tubes were required to give a sharp definition of the ribs. A couch was used; a wooden frame two feet wide covered with vegetable hair-cloth and a thin water-proof fabric so transparent that its shadow could hardly be noticed on the screen. The examinations were made in the evening in a dark-room kept at even temperature, and the patients were brought in without fatigue or exposure. A full physical examination of each case was then made by the usual clinical methods. The lines of dulness were then marked on the skin by a dermal pencil, and a lead-wire fastened over this to define the area on the fluoroscope. Afterward a second line was marked showing the areas of opacity revealed by the rays. Notes were then made as to the agreement or non-agreement of the different tracings. When working many hours in the darkness the eyes became able to see differences that at first escaped observation. All examinations were made in the following methodical manner:

* Archives of the Roentgen Ray.

1. Patient seated on couch with tube behind his back and screen placed on chest.

2. Tube in front of anterior wall of thorax and screen on back.

3. Patient in dorsal decubitus on couch; tube under couch; screen on thorax.

4. Patient laid on couch, first on right, then on left side, and tube and screen on opposite sides in alternation.

5. Lastly, examinations were made with patient on his abdomen.

Aware of the difficulties of the observations and the liability of error in interpretation a great variety of tests were made with many tubes in many different positions and at various distances, and every effort was made to arrive at correct conclusions. An attempt will be here made to so condense this immensely valuable report as to yield the greatest amount of instruction in the least space. We regret that the entire history of the cases cannot be included.

"Case 1.—Right pleuritic effusion due to chill. With the tube posteriorly and the patient sitting, the fluoroscopic opacity exactly coincided with the dulness. The lung above was transparent without any dark spot. The transverse lines in Fig. 1 represent the ribs. The left side was completely transparent, and here the movements of the diaphragm could be seen plainly. The apex of the heart followed the movements of the diaphragm and was lowered 2.75 centimetres in normal and 3 centimetres in deep inspiration, and beat exactly at the places where it was determined clinically. The collection of fluid (the opaque area) was raised by expiration and lowered by inspiration. On succussion no oscillation of the surface could be seen. (See Plates for illustration of the cases.)

"With tube in front, patient seated (Fig. 2), there was perfect transparency on the left side except along the spine, where there was an opaque area showing expansive movements synchronous with the systolic beatings of the heart. On the right opacity was seen extending upward to two fingers' breadth below the spine of the scapula. The lower margin of the opacity was horizontal, and the vertebral angle of the curve of Damoiseau was not apparent. The liquid was elevated with each movement of respiration.

"Fig. 3. Patient lying on back with tube under couch. Absolute transparency of the left side and total opacity of the right. The apex of the heart beat under the left nipple almost in its normal place, 8.5 centimetres from the median line and behind the fifth rib.

"Fig. 4 shows the right lateral decubitus with no interesting results. The limit of the opacity could be very plainly seen in this position.

"Paracentesis removed 2.65 litres of fluid, and the patient recovered fifteen days later.

"Remarks. The displacement of the heart was verified by the fluoroscope and was most marked in the sitting position. The apex of the heart followed the movements of the diaphragm. The surface of the collection of fluid followed the movements of respiration. Changes in position of the patient changed the gravitation of the fluid, and all the right half of the chest became opaque in dorsal decubitus. *The absence of any opaque spot in the lung indicated that there was no accompanying pulmonary lesion. This sign has an enormous prognostic value as it declares the integrity of the parenchyma of the lung.*

"Case 2.—Right pleuritic effusion of tubercular origin; paracentesis; removal of 2.8 litres of fluid and return of same with all symptoms three weeks later. Patient then examined with fluoroscope. Fig. 1. Tube behind the seated patient.

"All left side transparent except some opaque patches here and there. On the right side the opacity formed a complete curve, concave above; the higher part of which was two fingers' breadth below the limit of dulness. Between the upper part of this curve and the line of dulness was a slightly shaded zone, and there were some opaque patches in the lung above. The apex of the heart could be seen beating in the fifth intercostal space, four centimetres inside the nipple line. It did not follow the movements of the diaphragm, which were slight.

"Fig. 5. Tube in front, with patient seated. All the left side was transparent, except some opaque patches at the apex. On the right the apex of the lung was almost perfectly transparent. The fluoroscopic opacity described a curve with the concavity upward, the upper part of which was about five centimetres below the dull area, and the left arc of which ascended the spine some distance.

"Fig. 6. Patient in dorsal decubitus. Left side transparent. Complete opacity on the right. Apex of heart displaced and beat in the fifth interspace and on the nipple line. In the left lateral decubitus there was the same displacement of the apex. The patient died soon after, and an autopsy showed that the right lung was adherent by its anterior surface to the chest-wall and was immersed in the fluid. The fact that dulness described a curve with convexity upward, while the screen opacity reversed this and showed concavity upward, *was thus accounted for.* The more transparent lung adherent and dipping into the fluid reduced the opacity of the latter by thinning its density in the area occupied by lung-tissue. Were nothing but fluid in the cavity the upper line would be nearly level on the screen with the patient in a sitting position, but *with part of the fluid displaced its shadow varied according to its thickness*; this being greatest at the sides produced the curve. This case verified the conclusion of the Godard prize essay that in a right pleural effusion of 2.5 litres the apex of the heart is depressed and approaches the middle line; also, that this lateral displacement disappears in dorsal decubitus and in left lateral decubitus. We noted that in dorsal decubitus the fluoroscopic opacity occupied the whole of the right side of the thorax, which proves that the liquid was displaced and gravitated into the

Plate 153.—Case 1. Right Pleuritic Effusion from a chill. (Rebman, Ltd.)

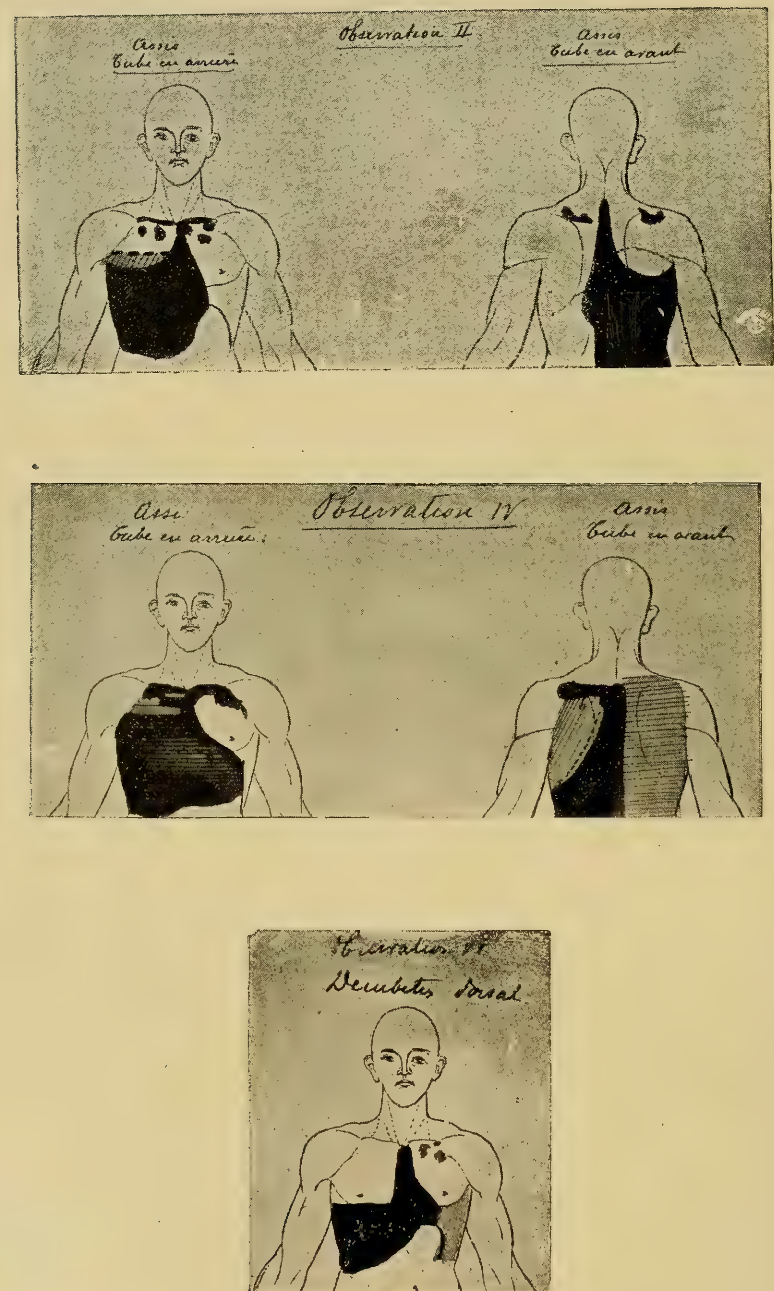


PLATE 154.—Case 2. Right Pleuritic Effusion—Tubercular with Adhesions.
(Rebman, Ltd.)

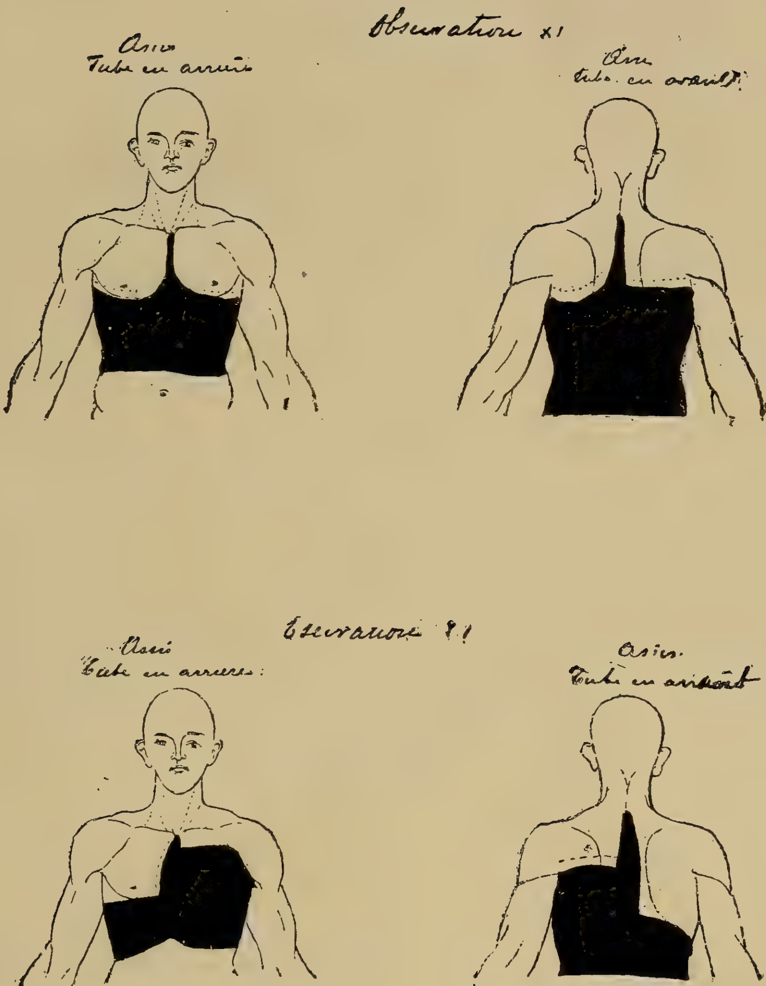


PLATE 155.—Case 3. Right Pleuritic Effusion. (Rebman, Ltd.)

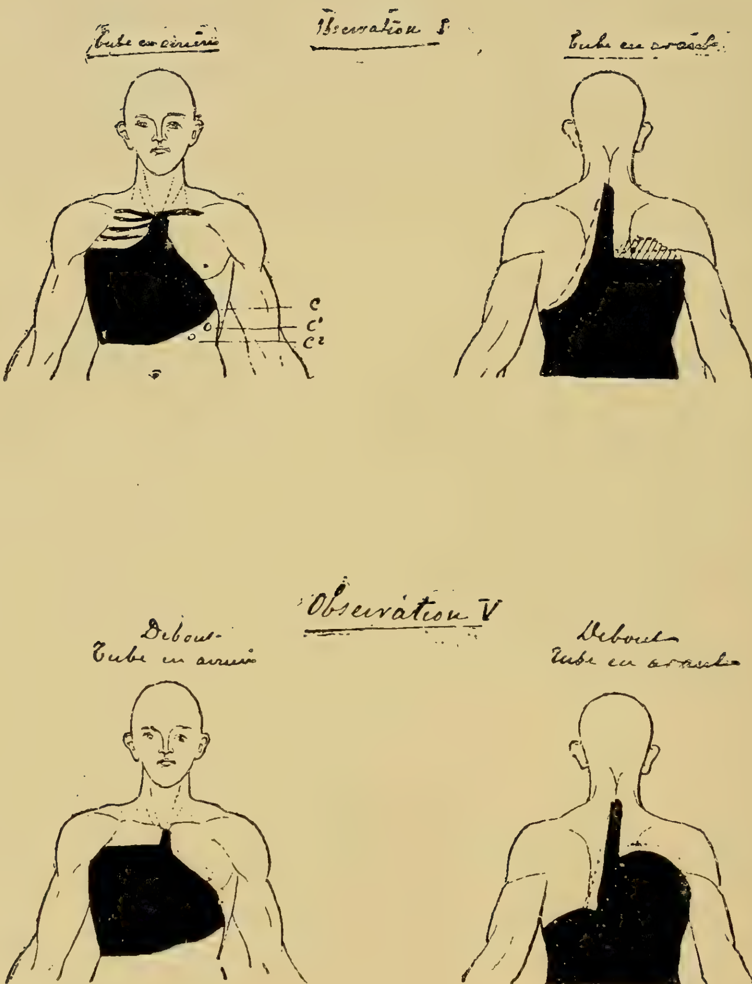


PLATE 156.—Case 3. Continued. Right Pleuritic Effusion. (Rebman, Ltd.)

costal groove when the patient was on his back. The opaque spots seen in the lung with the fluoroscope corresponded to tuberculous foci found at the autopsy.

"Case 3.—Male, aged twenty-two, acute pleurisy on right side following severe fall on edge of pavement. Tapping removed three litres of sero-fibrinous fluid, about half of which quantity reappeared a month later. Fluoroscope was then used.

"In this case three things seem worthy of remark. The displacement of the heart was less pronounced in dorsal decubitus than in the sitting position. The displacement of the fluid followed the movements of the patient and the movements of respiration. The line of opacity did not correspond with the curve of Damoiseau.

"Case 4.—Relapsing pleuritic effusions which had been evacuated four times in four months and supposed to be tuberculous infection. Fluid present estimated at two litres. Fluoroscope now revealed as follows:

"1. Patient seated with tube behind. Left side transparent except at apex of lung, where there were some irregular diffused patches which were doubtless foci of tubercular disease. The apex of the heart beat where it had been determined clinically, and rose two and one-half centimetres in normal and three centimetres in deep respirations. On the right there was complete opacity below the second intercostal space. Above that was a semi-clear area with dark spots.

"Fig. 12. Patient seated with tube in front. Almost perfect transparency of the left side except toward the upper part where, along the vertebral column, there was a dark triangular area, with its apex above and at the level of the second dorsal vertebra. This dark area was pushed to the right by each movement of respiration. On the right there was diffused opacity of the whole side.

"Fig. 13. In dorsal decubitus the same appearances were presented. The chest was tapped two weeks later and 2.2 litres of fluid removed. The next day a second fluoroscopic examination showed:

"Fig. 14. Patient standing with tube in front. Left side transparent except at the apex, where there were some opaque patches. On the right, disseminated opaque patches at the apex, with a semi-opacity of the lower part of the lung, much less in extent than before paracentesis, which presented a very curved outline with its concavity upward, and was raised with every expiration.

"Fig. 15. Patient standing with tube behind showed some opaque spots in both lungs. In this examination the following particulars are worthy of observation:

"1. The displacements of the heart, which followed the positions of the patient and the respiratory movements.

"2. *The opaque spots, indicating without doubt tubercular foci.*

"3. The existence of an opaque triangular area posteriorly, to the left of the spine, having expansive movements synchronous with respiration. This was probably only the mediastinum which was pushed to the left by each expiration.

"Case 5.—Male, aged twenty-five, right acute pleurisy with effusion estimated at two litres, the result of a chill.

"1. Fig. 16. Patient standing, with tube behind. Perfect transparency on the left side. On the right, complete opacity, except at the level of the first interspace, above which was absolute transparency. On the left the apex of the heart was seen beating in the fifth interspace, 13.5 centimetres from the middle line. It was raised 2.75 centimetres in normal expiration, and about 3.5 centimetres in forced expiration. (Other postures omitted for lack of space.)

"Paracentesis was performed February 25th, and about 2.5 litres of sero-fibrinary liquid was drawn off. The following points are worthy of note in this case:

"1. The displacements of the heart varying with the position of the patient and the movements of respiration.

"2. The oscillation of the surface of the liquid at each respiratory movement.

"3. The displacement of the liquid with each change of position of the patient.

"4. The displacement of the left of the mediastinum at each expiration, a phenomenon also observed in Case 4.

"5. *The perfect transparency of the right lung above the effusion, indicating the integrity of the pulmonary parenchyma.* This was eventually corroborated by the complete recovery of the patient.

"6. We would draw special attention to the shape of the upper part of area, which was *convex.* This indicated, in our opinion, that *there was no adhesion between the lung and the costal parietes.*

"Case 6.—Male, aged twenty-eight. Left pleuritic effusion, with some tubercular patches at the apex. (Details of postures and findings omitted.)

"The patient afterward became the subject of dorso-lumbar Pott's disease. The following points are worthy of note in this case:

"1. The displacement of the liquid in changes of position of the patient.

"2. Its displacement in respiratory movements.

"3. *The presence of shaded patches at the left apex, which indicated that tubercular infiltration was commencing there,* and this opinion was *verified* later by the appearance of moist râles in that situation.

"Case 7.—Left pleurisy from a chill with effusion estimated at 2.8 litres. Puncture evacuated 2.9 litres of fibro-serous liquid. The following points are worthy of note in this case:

"1. The perfect coincidence of the limits of the fluoroscopic opacity and the dulness.

"2. Displacement of the liquid with respiratory movements and changes of position of the patient.

"3. The movements of the upper level of the fluoroscopic opacity on forced expiratory movements, which seemed to corroborate the theory of Roesbach.

"Case 8.—Male, aged twenty-two. Left tubercular effusion.

"The following points are worthy of note in this case:

"1. It was not always possible to locate the apex of the heart exactly. It was not under the right breast, as the pulsation observed would have led one to suppose, but under the sternum.

"2. Displacement of the fluid in changes of position of the patient.

"3. *The existence of shaded spots at the apex of the lungs which led us to think that tubercular infiltration was beginning in the lung-tissue*, and this was *verified* later in the case. The day after the examination 3.10 litres of fluid were evacuated.

"Case 9.—Female, aged twenty-six. Purulent pleurisy. Two litres of pus evacuated. The effusion reformed and she became hectic. The fluoroscopic examination then showed: (Details omitted.)

"This observation scarcely gave any precise results. It showed, however, that in *left* pleuritic effusions no decided conclusion had been come to as to the position of the apex of the heart from a fluoroscopic examination. It is interesting to note, however, that purulent liquid arrests the passage of X-rays through it nearly as much as does sero-fibrinous liquid; but the opacity is less *complete* in the former than in the latter, since, through the former, the shadows of the ribs may be perceived. *This may perhaps prove to be important in making a differential diagnosis.*

"Case 10.—Female, with signs of considerable left pleuritic effusion; nevertheless, four exploratory tappings gave only negative results. After a careful clinic examination a diagnosis was made of tubercular infiltration of the left lung with slight pleuritic effusion. A fluoroscopic examination was next made.

"1. Fig. 29. Patient seated with tube behind. Almost perfect transparency of the right side, except at the apex where there were some opaque spots of small extent. On the left the upper limit of the opacity followed exactly the line of clinical dulness. The upper part slightly shaded with a diffused opaque patch in it. There was a very dark area running obliquely down the sternum and toward the right nipple, and continuous with the main dark area below. On the right side the convexity of the diaphragm was well marked. The shaded area down the sternum passed the middle line to the right at each expiration, and went back again at each inspiration. These movements were absolutely synchronous with those of the diaphragm. The outline of the heart could not be seen at all, as its shadow was within the dark area.

"2. Fig. 30. Patient seated with tube in front. Perfect transparency of the right side, the movements of the diaphragm being well seen. On the left the line of opacity corresponded at its upper limits to that of the dulness, and described a curve with its concavity upward.

"It was convexed toward the right and extended above the shoulders to the second dorsal vertebra (mediastinum).

"Fig. 31. In dorsal decubitus. On the right the result obtained was the same as in the sitting posture. On the left was opacity, which, instead of being limited as in the sitting posture, occupied the whole of the chest.

"4. Fig. 32. In ventral decubitus, the right side presented the same characteristics as in the previous positions. On the left there was diffused opacity of the whole side.

"5. Fig. 33. Right lateral decubitus with the tube behind. Transparency on the right side. On the left, some opacity.

"6. Fig. 34. Tube in front. Right side transparent. On the left there was a triangular opacity running up the spine with its base below reaching from the spine to the axilla. The points worthy of note in this observation are:

"1. Displacement of the fluid in changes of position of the patient.

"2. The importance of the fluoroscopic examination as it *revealed the existence of the foci of tubercular infiltration in the lungs.*

"3. Displacement of the mediastinum toward the right during the expiration, which will be explained presently.

"4. The form of the upper limit of the opacity which was *opposite* to that of the classic curve of Damoiseau. This *anomaly* received a natural explanation in the sequel.

"The patient ultimately died, and a post-mortem showed that *the left lung was adherent by its anterior surface to the walls of the chest*, and was consequently *immersed in the effusion*, causing it to give at its *upper* part only a semi-opaque shadow and throwing the upper margin of the opaque liquid out of shape.

"Case 11.—Male, clinical diagnosis; tuberculosis of the peritoneal pleura, with double pleuritic effusion of a tubercular origin. This diagnosis was verified by exploratory tappings. He was next examined with a fluoroscope.

"This case was interesting from several points of view. We may note:

"1. The verification by fluoroscopic examination of the clinical diagnosis of a double pleuritic effusion.

"2. Displacement of the fluid in respiratory movements.

"3. The movements communicated to the collection of fluid on the left side by the pulsation of the heart.

"4. The horizontal line of the water-level on the right behind.

"In our opinion these observations in their relations to the clinical facts noted before each of them lead us to some interesting deductions. It has been shown that pleuritic effusions do not allow X-rays to pass through them, and that the hemithorax affected presented a very marked opacity on the screen. It seems to us that *this opacity is directly in proportion to the amount of effusion.* When there is a collection of *pus* in the pleura the opacity seems less complete than when there is an effusion of *serum.* In the former case there is only a dimness, more or less considerable according to the amount of effusion. The lower boundary of a pleuritic effusion is as a rule but

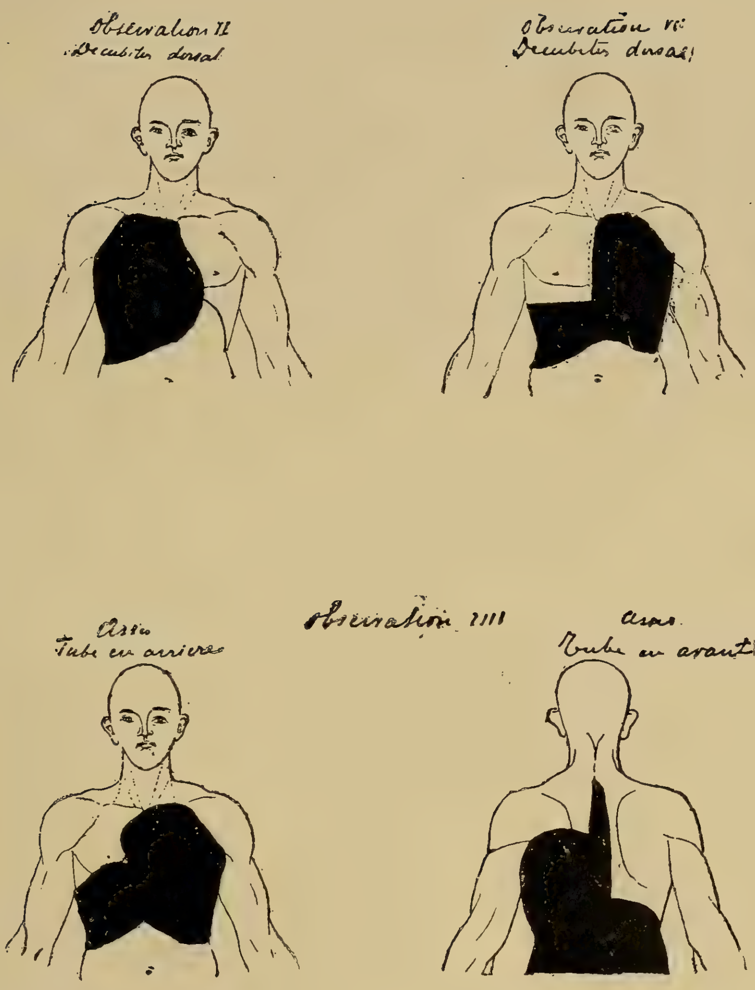


Plate 157.—Case 4. Right Pleuritic Effusion of Bacillary Origin. First Examination. (Rebman, Ltd.)

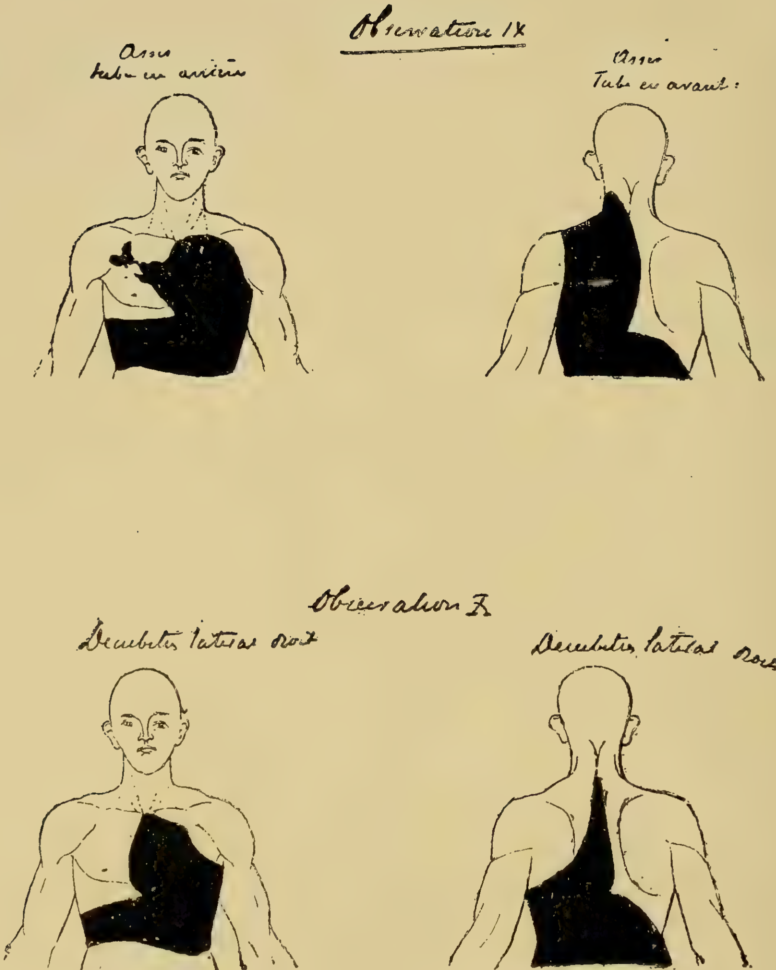


PLATE 158.—Case 4. Continued. Second Examination—after Tapping. (Rebman, Ltd.)

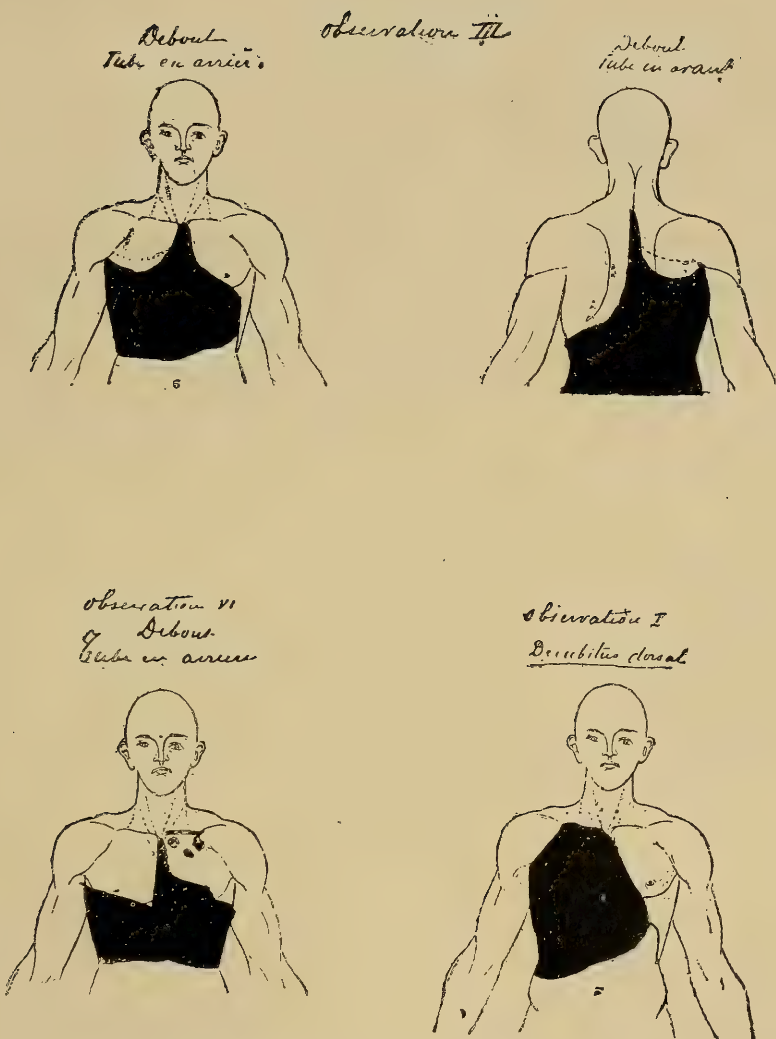


PLATE 159.—Case 5. Right Pleurisy from a Chill.

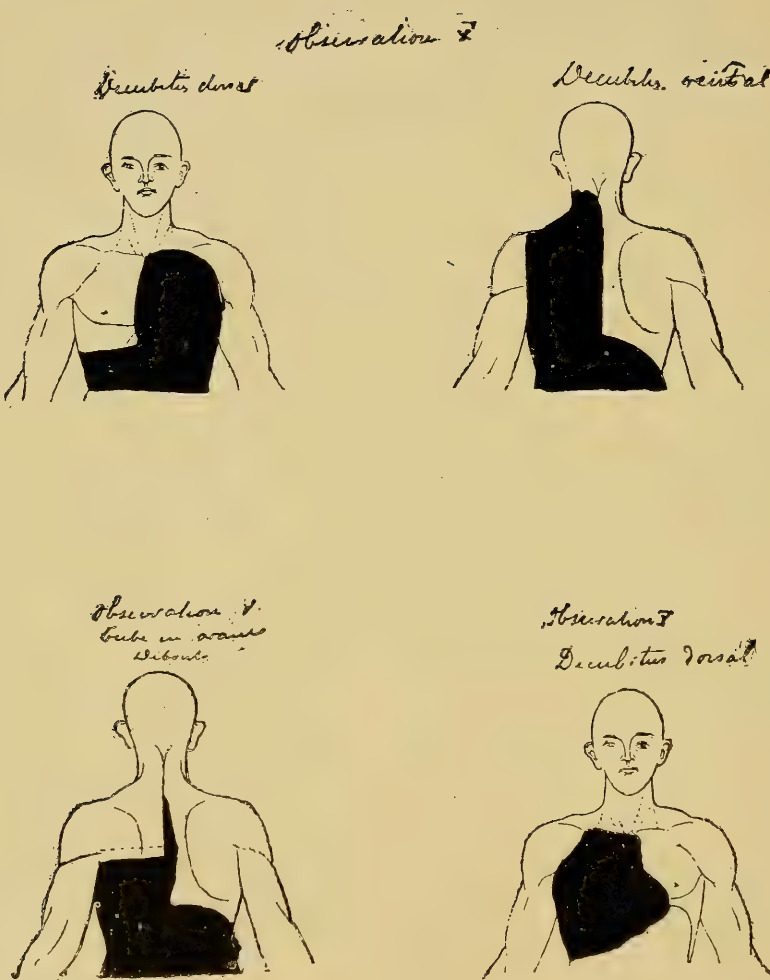


PLATE 160.—Case 6. Left Pleurisy with Effusion—Tubercular.

little defined, especially on the right, where it blends insensibly with the opacity caused by the liver. The upper boundary is generally very clear and sharp, and presents variable appearances:

"It may coincide with the curve of Damoiseau.

"It may be concave above (opposite to that curve).

"It may be horizontal.

"When the upper surface of the liquid presents (both to percussion and to the fluoroscope), the classic curve of Damoiseau, *we may be sure that the convex part corresponds to a hyperæmic or atelectic area;* for if we make the patient cough violently, or take four or five deep inspirations, we may see that the surface becomes horizontal instead of convex. Often the upper margin is horizontal, even when the line of dulness or percussion follows the curve of Damoiseau. Lastly, in some rare cases the upper limit of the opacity is *concave* above. We have seen some such, and we think that we can explain the phenomenon. In these cases *the lung which is adherent to the costal parietes, dips more or less deeply into the liquid, and the upper part of the effusion occupied also by the lung is partly transparent, and thus the margin of the opacity seems to be concave above.*

"It is by no means rare to see alterations in the shape or situation of the upper surface, and these are sometimes synchronous with the pulsation with the heart. More frequently, however, these alterations are caused by inspiration or expiration. The surface is lowered by the former and raised by the latter. This phenomenon is easy of explanation, for *in expiration the cavity of the thorax becomes contracted and the compressed effused liquid is raised.*

"M. Mignon says that in hydropneumothorax the movements of the patient cause an agitation at the dark surface of the liquid. We have never been able to get this wave-like movement in any cases we have examined. We do, however, get displacements of the whole collection of the fluid with changes of position of the patient. We have been able to convince ourselves of the presence of such displacements by percussion, and have afterward found them even more evident on the fluoroscope. In dorsal decubitus the fluid collects in the posterior thoracic grooves, so that there is no margin to the opacity and all the side is opaque. There is also total opacity in ventral decubitus.

"It is in the study of *displacements of the heart* that the fluoroscope renders us the greatest service, since percussion and the phonendoscope give only negative indications on this subject. Thus, we have observed that in effusions on the right side of *small amount* there is little or no displacement of the apex in *dorsal decubitus.* When the patient has been caused to *sit or lie on his left side* we have seen a displacement toward the left from three to five centimetres. In a healthy man we have never seen the heart displaced by changes of position in this way, but, though there is no lateral movement, it is *lowered* two or three centimetres in inspiration. With effusions on the right of *considerable amount* we have noticed displacings of the heart to the left, but changes of position do not make much difference to it. In *left-sided effusions* the problem is more interesting, for here we touch the grave question of the possibility of torsion of the heart. One of us, in an essay to which a prize was awarded by the University of Bordeaux, July, 1897, gave the experimental and clinical reasons which were opposed to the possibility of such torsion taking place.

Professor Bouchard has demonstrated the existence of *an opaque area to the right of the spine which disappears on expiration.* He thought it was produced by the dilatation of the right auricle. We have observed it in one case, but what we have more often noticed is the existence of a triangular opaque area to the right of the spine increasing in size with expiration and diminishing in inspiration. It is probable that this is due to displacements of the mediastinum. During expiration the depression in the left pleura, when it encloses the effusion, attains its maximum, and the only one of all the parts bounding the thorax, which is movable and passive during expiration, is the *mediastinum*, the diaphragm being contracted. It is, consequently, *driven to the right in expiration.* The fluoroscope also allows us to study the movements of the *diaphragm* in pleuritic patients. The half of the arch which corresponds with the effusion scarcely makes any movement, while the other half makes up the deficiency by exaggerated movements. Lastly, we may add that by the aid of the fluoroscope we may pretty accurately form a *prognosis* in cases of pleuritic effusion. Many authors have insisted on the value of the fluoroscope in the early diagnosis of tubercle in the lung. The honor of having first made that important discovery belongs to Professor Bouchard, December, 1896. In all our researches we have carefully examined the state of the pulmonary parenchyma above the effusion, and we now feel in a position to draw the following conclusions: *When the thorax above the effusion is uniformly transparent the prognosis is good, and there is no fear of pulmonary tuberculosis.* It is quite a different thing, however, *when opacities of more or less irregular shape, which do not disappear with deep inspiration, are found above the liquid.* Then it is a question of bacillary infiltration and our prognosis must be guarded."

In this important chapter there are so many valuable diagnostic hints that the student should read it over to refresh the memory just before making his examinations, till experience makes him familiar with all its points. The careful study of the preceding chapter at the same time will discover a great many suggestions affecting both diagnosis and prognosis. The entire field is so thoroughly cleared for the beginner that, with this instruction at hand, there will be neither excuse nor occasion for the *general practitioner* to delay taking advantage of the immense utility of X-rays. It is hoped that the plain directions here set forth for their use will relieve many from the deterrent influence of imaginary difficulties which have little existence in fact.

CHAPTER XXXVI

EXAMINATIONS OF THE STOMACH AND ABDOMEN

In writing up his "cardiameter" McCaskey describes its use for measuring the distance from the incisors to the cardia, and also for defining absolutely the position of the latter by the aid of the X-rays. In the distal end of a soft rubber colon tube is placed a tightly fitted piece of metal tubing, over which is adjusted a small bag of very thin rubber, the end of which projects about an inch beyond the tube. The proximal end is attached to a closed rubber bulb. Compression of the rubber bulb expands the bag, which collapses when the bulb is relaxed. A centimetre scale is placed on the tube, measuring from the distal end. The tube with the rubber bag collapsed is introduced into the stomach and expanded with air by compression of the bulb. It is then withdrawn until the impact of the rubber balloon is felt against the cardiac orifice. Passing the writer's description of its general diagnostic uses, we cite his closing remarks.

"So far my investigations along these lines had been with exclusive reference to the precise distance of the cardia from the incisors with a special reference to the use of intragastric appliances. At this point it occurred to me that by fixing a piece of metal at the cardia and taking a radiograph with suitable surface landmarks made by the shadows of metal, the precise position of the cardia with reference to the surface of the body could be determined. This proved to be entirely feasible, and I present herewith a radiogram demonstrating the result in a case of extreme ptosis. By this means at least one point in the upper border of the stomach can be mapped out on the surface with absolute precision."

The Gyromele in X-Ray Diagnosis.—The "Gyromele" is a flexible steel cable, practically a revolving sound, with spiral end provided with a metallic pellet covered with wool, cotton, or sponge, and operated by a revolving drill handle. From an extensive article by Turck, we take sufficient description to explain its modus operandi and the particular uses of X-rays.

"The following cavities have been explored successfully with the gyromele: the œsophagus, the stomach, the pylorus, the small intestine, colon, bladder, uterus, thoracic cavity, nose, and throat, and false cavities of various characters. After introduction into an accessible cavity of the body the revolving apparatus is put into motion, and the rotation of vibrations caused in varying degree which are transmitted through the tissues, are perceived externally by palpation and auscultation. Cables of different calibre and length have been devised to provide different degrees of flexibility and elasticity, and thus broaden the scope of usefulness of the instrument for different purposes.

"It is not only its extraordinary adaptability, flexibility, and elasticity which enable the instrument to enter cavities hitherto inaccessible, but it is the *rotary motion* which adds greatly to the safety and facility of the device. Since the delicate rotations gently wend their way through any possible narrowing, and these rotations can be followed externally by the ear or the finger, we are enabled to gain valuable information of cavities which were formerly inaccessible. This information is not limited to anatomical data, situation, extension, capacity, and so on, but we may obtain valuable facts as to contents of the cavities, adherent masses of mucus, bacteria, etc., by means of specially constructed terminals. The flexibility of the gyromele is of such a degree as to adapt itself to the situation, shape, and size of the organ explored, particularly the stomach.

"By means of the revolving-drill apparatus, to which the sound is attached, vibrations are produced which can be palpated and ausculted externally, thus giving us exact information of the presence and locations of the revolving table. The situation of the metal sound can also be verified by means of the X-rays. The fluoroscope and the radiograph both give excellent results. By transillumination of the patient with the X-rays it can be clearly observed how the metallic sound makes its way along œsophagus through the stomach and pylorus, and into the small intestine."

After setting forth its important uses in connection with the diagnosis of diseases of the stomach and intestinal tract, Turck thus continues:

"By the use of the X-rays diagnosis by means of the gyromele cable, combined with palpation, is made more certain and easy. The technique of employing it for examination of the stomach is simple. The cable is introduced in almost the same manner as the ordinary stomach-tube. Some experience is required to locate the fundus, greater curvature, pylorus, and lesser curvature, with certainty, but even the inexperienced find the introduction of the thin cable, covered with rubber tube, the thickness of which reaches at most only five or six millimetres, and armed with the soft cotton tampon or sponge, easier than the introduction of the thicker and flabby stomach-tube. This is particularly the case with patients unused to intragastric methods.

"The rotating cable is covered the distance from mouth to cardia with a rubber tube. In this tube, the cable moves freely, and thus little friction is caused. Since this surrounding rubber tube remains stationary, a pushing to and fro of the cable is unnoticed by the patient. As soon as the tampon on the end of the cable has reached the greater curvature, it meets slight resistance, the cable bends, and the end glides along the greater curvature until at the antrum pyloricum, or lesser curvature, it again meets resistance. Now, the stomach is moderately inflated with air and the cable pushed slowly forward; its end now turns—as has been observed by the X-rays—toward the left and upward along the lesser curvature. Thus the cable is seen to describe an irregular circle, influenced by the contour of the stomach. Pushing the cable still farther into the inflated stomach, it will bend into the fundus, there adapting itself to the dome thereof. All of these phenomena can be observed with as much certainty by external palpation and auscultation of the rotating cable end, as with the X-ray. This holds true, even of those parts which are covered by the left lobe of the liver or by the ribs. By following the rotations of the cable end with a skin pencil the contours of the stomach are drawn upon the abdominal surface. The first attempts to observe the introduced sound *in situ*, with the aid of the X-rays, were made in the spring of 1896. The density of the steel sound is seen to interrupt the rays and give a distinct contour of the sound. It is extremely interesting to observe the excursions of the rotating cable with the aid of the X-rays or the entrance of the end of the cable into the pylorus or duodenum. I have often found the borders of the stomach, previously marked by lead roll fastened upon the abdomen, confirmed by transillumination. The ensiform appendix and umbilicus were marked with metal buttons, and their position was also confirmed.

"Measurements were made by graduating the cable with lead shot. All those experienced in the *diagnostique* of the stomach and intestines will readily appreciate the value of this method. It is easily seen, when applying bismuth-salt emulsion, by means of the gyromele, that the walls of the stomach and œsophagus become thoroughly coated with a stratum of the emulsion."

Read also the section on accessory shadows as aids to diagnosis in the chapter on the art of reading X-ray shadows.

Examination of the Abdomen with X-Rays.—Blacker has offered the following remarks on this subject:

"It is not always easy to find a bullet within the abdomen, although large and undoubtedly present. That a mass of metal may be embedded within the abdomen without being visible on the fluorescent screen or on the developed film is known to most of us, and the reason for this is that the spent projectile having only sufficient force to penetrate the abdominal wall and to become embedded in some of the many soft structures which occupy the cavity *moves* very freely with respiration. The blurring effect of this movement is much greater than any one not accustomed to work with the fluorescent screen would imagine, the length of the shadow thrown depending to a great extent on the distance of the foreign body from the screen, on the movement which takes place during respiration, and on the movement of the intestines in the neighborhood of the bullet.

"We were familiar with the movement which takes place in the abdominal cavity during examination for foreign bodies which have entered through the alimentary canal, or through the abdominal walls, which renders X-ray examination difficult, and failures in examining for renal *calculi* did not therefore appear hard to understand, considering that in addition to this movement search was being made for a substance which (according to its composition and size) might or might not throw a shadow on the sensitive surface. But with a metallic substance, which as a rule gave a dense shadow, it did not at first seem conceivable that the blurring of the shadow caused by the movement would be sufficient to render its discovery difficult and its localization impossible without definite precautions being taken. Such, however, is the case. In the case of all opaque substances it is customary now to examine during one phase of respiration only. This to a certain extent does away with some of the difficulties, but it is difficult even with a mechanical arrangement denoting the position at which the exposure is to be effected at each succeeding respiration, to prevent some blurring of the shadow caused by movement of the abdominal contents; for even if the relative position of the bullet can be made out the exact localization is not easy.

"The chief difficulties which present themselves when examining the abdomen with the X-rays for the localization of a bullet are:

"1. The distance of the bullet from the screen or film.

"2. Possible astigmatic action of the tube. (Use a tested tube.)

"3. Movement of the bullet with the tissues within the abdominal cavity which may be caused by respiratory, or intestinal movements, or by pulsation of vessels.

"4. Involuntary movements on the part of the patient during exposure.

"5. Effusion of blood if the case be one of recent origin.

"6. The presence of dense inflammatory material in old cases.

"In order to obviate as far as possible these difficulties, it is necessary to place the screen or film as near as possible to the supposed position of the bullet, and to direct the rays so that no opaque tissue intervenes between the tube and the bullet, or between the bullet and the screen. The respiratory movements can be controlled to a certain extent. Intestinal movements may be controlled by drugs. Involuntary movements on the part of the patient can always be controlled by an anæsthetic, if not by strapping.

"For the purposes of exact localization there may still be opaque tissues obscuring the shadow which cannot be avoided, such as adipose tissue, bones, well-developed muscles, pulsation in the neighborhood, and effusion of blood. These remarks apply only to bullets embedded in the movable tissues of the abdominal cavity. Those embedded in a fixed position present no particular difficulty in an X-ray examination."

The intestinal organs are most at rest when there is no food in the stomach and after thorough cleansing of the tract by purgation and enemata. In an important case allow twenty-four hours for this preparation. This applies to both abdominal and pelvic examinations. Still further restriction of movement may be secured by opium; or, without a narcotic, by a thin and tight muslin binder. Complete anæsthesia to secure physiological rest during an exposure will be a last resort and can be employed when indicated. Or, if the patient is being anæsthetized for an operation, the occasion may often be opportune for a quick exposure and rapid revelopment of the plate for the surgeon's guidance. Suitable facilities enable this to be done with practically no interference with the surgical preparations for work.

In our next chapter we will take up the uses of X-rays in therapeutics, a subject which is fast attracting the attention of practitioners, who will find in this section the explicit instructions they require for the treatment of their own patients.

Studies in X-Ray Therapy

"*Flattering reports from so many workers in this field forces upon us the conviction that a new era in the treatment of certain rebellious diseases of the skin is now opening, and that a new agent has come which will occupy a high place in dermato-therapy. It has been the criticism of many that we have recurrences after this treatment! But is this not so of all other known methods? Can we insure a patient that his epithelioma will not recur after removing it and a wide margin of his integument with the knife? Can we tell him it will not recur after having him spend hours of pain under the arsenical pastes? Can we promise a lupus patient freedom from his disease after months of pastes, caustics, plasters, salves or lotions? These diseases will often recur after any method, and if they do after the X-rays, there is no form of treatment as painless, simple, and easy by which to treat the recurrence. It is particularly applicable to these cases, as the ease of its application relieves the despondent, discouraged and timid patient of all fear of active or painful procedure.*"
—(Inter-State Medical Journal, December, 1901.)

CHAPTER XXXVII

EMPIRICAL NOTES

The Beginnings of Scientific X-Ray Therapy. A Chapter Containing Much Varied Instruction and Information.

The faithful reader of current medical literature may recall that many mentions of X-ray therapeutics have floated before his eye, yet when a particular case enlists his interest he is apt to find that scattered abstracts are vague memories without detail. For this reason the review of a selected number in an orderly study will not only enable us to judge how far X-rays may be credited with therapeutic actions, but will suggest hints for personal application in our own cases. We therefore feel that the clinical beginnings of X-ray therapeutics will interest and enlighten a large majority of the profession, and, probably, no chapter in this book will better repay study. Beginning with one of the earliest mentions that we find in print, the remaining abstracts will not attempt a regular chronological order.

"In March, 1896, Schonberg began the treatment of two cases of lupus. The first was a young man who had been treated early in 1895 with scraping, iodoform, cauterization, nitric acid, etc., and in 1896 with tuberculin without results. X-ray therapy was carried out in the following manner: the patient was stretched out on a table and a tin-foil mask put over the entire portion of the face which was not affected by the disease. A cap of tin-foil also covered the head. The tube was ten inches from the face. A coil was used and daily exposures of twenty to thirty minutes were made. In seventeen days, on April 4, 1896, the exposed surface showed a very distinct reaction and redness, and four days later the dermatitis was general. From this moment the ulcerated portions gradually yielded and recovery resulted. In the second case, that of a woman forty-eight years old, the same method was employed with equally satisfactory results.

"Ullmann reported in a German paper a case of severe *acne of the back* in a patient aged sixteen, treated by the X-rays. Fifty exposures of half an hour each were given. After fifteen sittings the acne spots swelled and there was a diffuse erythema of the skin. Afterward the acne spots shrunk, while the skin over them exfoliated.

"Early in 1898 Gautier reported three cases of facial *acne* treated by X-rays, one being as follows, after the failure of many other attempts to cure: A medium Crookes tube was used and enveloped in a black cloth to shut out the electric-light radiations. It was excited with a coil taking in the primary four amperes at twenty volts. The eyebrows, eyelashes, and hair were protected by a cover of flexible lead bent to fit the shape of the skull. The tube was twelve inches distant. Exposures daily for five or six minutes. First one side of the face was treated and then the other. The result began to show itself after six treatments; the skin peeled, the pimples became less red, and the glands less apparent. No accidents or ill-effects occurred during these treatments."

"Dr. Leopold Freund, March 6, 1897, reported the X-ray treatment of a pigmented and hairy *nævus*, reaching from the nape of the neck down almost to the folds of the nates, and extending over the whole back, the sides of the thorax, the shoulders, and the upper half of the right arm. The back was exposed daily for two hours at a distance of four inches from the tube. For ten days no effect was produced, but on the eleventh day the hairs began to fall out in bundles and continued to do so to an increasing extent for eight days, when a slight dermatitis appeared which soon yielded to ichthyol. By this time the neck and inter-scapular space had become quite bald. No new growth had taken place within six weeks. [It is assumed that during the two-hour seances the rays were directed to different areas so as to attack a single part but a short time.—Ed.]

"About a year and a half later Freund and Schiff reported further on two *lupus* cases and seven *epilation* cases. In their cases of epilation they had obtained the best therapeutic result after from seventeen to thirty short exposures. In several cases they noticed that one or two days before the hair fell out the skin showed a brownish discoloration, which disappeared three or four days after the hair fell out. In several brunettes the hair became white before it fell out. The effect of the rays is cumulative. They also state that Jutassy has, since Freund's first publication, treated forty cases of *hypertrichosis* by X-rays, and in some of them there has been no regrowth of hair after a year.

"Dr. Leigh reported a case of a young man with a *bullet in the thigh.* At the time of the examination the knee was very much swollen, exquisitely tender, and painful. The slightest touch or motion made him cry out in agony. Having at that time an imperfect coil and poor tube the surgeon exposed the knee to the X-rays for four hours in the attempt to get a radiograph. Failure delayed the operation. The next day the patient moved about the bed without pain; the second day he was up in a chair, and the third day he was walking about on crutches. A second case was one of *tuberculosis* of the elbow-joint. Professor W. advised excision. Another consultant advised the use of the X-ray. The joint was exposed two and three times a week for two hours at a time till the total application equalled twelve hours. A wet dressing was applied after each treatment. In a short time all signs of inflammation had disappeared, and now eighteen months have passed without any return of the disease.

"The third case was an examination for *gall-stones*. For several months the patient had been suffering frightful attacks of pain at frequent intervals. No stones were found by the examination, which was prolonged. Since the examination, however, the man has not had an attack and is in perfect health. A third and fourth case of a similar nature were also apparently relieved by the use of the X-ray.

"Dr. G. Cantrie reported the cure of a *varicose ulcer* by exposures to X-rays. Between November 5, 1898, and February 1, 1899, eight exposures were made with the tube ten inches from the surface of the ulcer. The first seance was five minutes, and all following were ten minutes.

"From Germany was reported the cure of a case of 'undoubted *tuberculous peritonitis*' by the X-rays. The patient was a girl aged nine years. Tapping, abdominal section, repeated tapping, and washing out with a creosote solution had negative results. She grew steadily worse, and the tuberculous masses in the abdomen steadily enlarged during treatment. First X-ray exposure was for ten minutes with tube eight inches from the abdomen. Two days later a second exposure of ten minutes was made at five inches. These were repeated for a month at intervals of two or three days. Treatment was then stopped for a month for extraneous reasons, but the patient returned and was treated another month. By the end of two months net treatment there was absolutely no abdominal effusion. From this time she gained steadily in weight and strength till she became apparently well. No dermatitis appeared. There was a slight pigmentation of the skin of the exposed region which could still be seen three months after treatment ceased.

"Jutassy reported in August, 1900, the following cases treated by X-rays:

"1. *Lupus vulgaris* in a woman aged twenty-four. Exposed the part to an intense current at seven sittings, with a total duration of four hours. The patch of lupus became a bleeding raw surface, which healed under antiseptic dressings in a month and formed a smooth scar.

"2. *Lupus erythematosus* of the nose and face in a woman aged twenty-eight; duration of disease eight years; seven treatments were given, having a total of five and one-half hours exposure. The central skin of the diseased area came off in a thick layer. A second series of six exposures with a total duration of three hours. Soon after this the surface of the lesion desquamated, and the face was clear and remained so for eighteen months, when there were some small recurrences.

"3. Chronic *eczema* in the hand of a man aged twenty-nine;

duration of disease eight years; eight exposures were made, with a total of two and one-half hours. A crust formed on the affected skin, this healed and left the skin healthy.

"4. *Hypertrichosis* of the face and neck in a man aged twenty-five; ten sittings were given, with a total exposure of three and one-half hours. Two weeks afterward the brownish erythema appeared and the hairs were completely shed. Two months later new hairs grew at the angle of the mouth and a second series of sittings was given, combined with electrolysis of some of the larger hairs. A good result was obtained.

"5. *Port wine mark* in a man aged twenty-two; ten sittings were given, aggregating fourteen hours exposure; the eyebrows, upper lip, and eyelids being protected. A pustular dermatitis resulted which healed under simple dressings. Three months later the nævus had disappeared and was replaced by a smooth whitish scar. Unfortunately pigmentation appeared at the edge which resisted all treatment.

"6. Treatment of a *Port Wine Mark* upon the face by X-rays.

"The patient was a man aged twenty-one. The mark covered the whole of the right side of the face and involved the mucous membrane of the mouth and nose. A small portion of the middle of the cheek was experimented on at first, the rest of the head and face being protected by a lead mask. Exposure was continued till a strip of sound skin showed a slight degree of hyperæmia. Ten days later this strip became deeply pigmented. One month later it was noted that the exposed portion of the nævus was distinctly paler than the rest. Treatment was then begun again, and a much larger surface was exposed till a definite erythema was produced a second time. On this occasion the epidermis was completely detached, and the corium beneath was exposed. The sore left was about two months in healing. At the end of that time the result was phenomenal. The nævus had gone. In its place was a smooth, soft scar, if a rose-red patch of skin can be called a scar. Only at the edge was a little brownish pigmentation. A year and a half later the greater part of the skin was nearly normal, and the mucous membrane on the nose was much paler. In winter the color of the skin becomes a little deeper, but this is only temporary."

"*Neuralgia* treated by X-rays. Stembo was led to make use of this method for the purpose of relieving neuralgic pains by the fact that sometimes patients report relief from pain when the rays have been employed for merely diagnostic purposes. A coil giving a twelve- to eighteen-inch spark was used, the rate of interruption being about 1,500 per minute. The distance of the anode varied from eight to twenty inches from the part affected. If the part was comparatively insensitive or the pain deeply seated the patient was insulated, but not otherwise. If the face was affected the skin over the part which was not painful was protected with tin-foil. Sittings were from three to ten minutes, and every second day. Relief was generally reported after the third application. To derive benefit the electrostatic field must be strong enough to cause a slight pricking sensation when the patient is touched by the operator."

"Dr. Hahn before the medical society of Hamburg in November, 1900, stated that there was an increasing interest in the treatment of skin diseases by the use of the X-ray; and introduced for their examination some of the patients who had been so treated. He placed lupus in the foreground of interest. He also claimed to have treated with good results eczema, psoriasis vulgaris, lupus erythematosus, rosacea, favus, sycosis, and hypertrichosis. He stated that 'it goes without saying' that the treatment is alike beneficial for both acute and chronic eczema. The doctor presented a case of eczema in a young lady of seventeen who had suffered from it in malignant form since earliest childhood, satisfactorily proving a complete cure as the result of the X-ray treatments. These diseases respond quickly to the Roentgen rays, particularly in the suppression after one or two treatments of the itching that is the accompaniment of eczema. Psoriasis cases were equally benefited by the X-ray treatment, the scales dropping off at from four to six exposures without the characteristic bleeding. Of lupus erythematosus he reported three cases. Of these two cases were positively cured; of the third he could only report apparent good results while treatment was continued, but the patient went away and the case was lost sight of.

"In two cases of rosacea, the cures were at least long-lasting, if not complete, as there had been so far no return of efflorescence upon the skin. In cases of reddening of the nose, the X-ray seemed to destroy the germs at once. He said the triumphs of the X-ray treatment have been marked in all diseases of the skin which, as a rule, accompany hair diseases, remarking that to cure the first it was necessary to remove the hair. Speaking at length, he remarked, that in the two cases of favus mentioned, compared with cases otherwise treated, the preference was decidedly in favor of the X-ray. In a case of sycosis, in which positive cure was effected by the X-ray treatment, the doctor stated, that after a few exposures the swellings the size of walnuts fell off, the hair disappeared, and the inflammation went back, the affection disappearing with the healing of the slight burning caused by the X-ray. In the cases of sycosis mentioned excellent results followed, though they had been persistent for from two to twenty years. In the specially demonstrated case, the affection had been existing for six years. The hairs were sticking in the inflamed follicles on both cheeks, chin, and upper lip; the main parts between were red and infiltrated. After twenty-three treatments with the X-ray an excoriation of the chin about the size of a nickel appeared, but quickly yielded to emollients applied. After the cure of the excoriation, the chin and cheeks appeared in an entirely normal state, though the upper lip remained slightly reddened. The results are unfailing and cure can be guaranteed. In the growth of hair, which occurs in from two to four months, the recurrence becomes less and less, until finally they will not grow again; the skin stays smooth and no scars or observable change appears."

As Schiff and Freund of Vienna have been two of the most prominent pioneers in connection with X-Ray Therapeutics, it will be instructive to study the conclusions of their report in August, 1900, after more than four years' experience.

"The influence of the X-rays on the skin consists first in a relaxing effect on the deep vessels of the corium, and an effect with which is certainly associated a slight exudation into the tissues of the epidermis and cuticle. This process causes a swelling of the hair papilla on hairy parts of the body, and, consequently, also a detachment of the hair bulbs. In cutaneous affections with inflammatory infiltration and new growth of young tissue the cellular formative elements get altered in their molecular composition and thus prepared for absorption. Whether the X-rays act injuriously on micro-organisms, or whether it is only that phagocytosis, becoming more pronounced under the inflammation, proves serviceable in parasitic affections of the skin, has not yet been determined even after four years of research. Among indications which call for treatment with X-rays may be enumerated abnormal growth of hair, and all cutaneous diseases caused or prolonged by the presence of hair, as sycosis, favus, wounds of the hairy parts of the body, and trichorrhexis nodosa; and as furunculosis, acne, lupus vulgaris, lupus erythematodes, eczema, and elephantiasis.

"The method is very simple. *The tube at six inches from the skin is so placed that the anode stands exactly opposite and parallel to the irradiated field.* Sittings are daily held; at first five, and, later on, ten or twenty minutes. The distance of the tube may also be slightly and gradually lessened. The parts not diseased are protected with a sheet of card-board covered with lead-foil one-fifteenth of an inch in thickness in which holes are cut to fit the diseased area. As these 'leaden masks' may be used by several patients, or more than once by the same patient, they are lined with card-board, which is alone in contact with the tissues and which can be thrown away after each sitting. *As soon as the skin appears turgid, or shows a pale pink or brownish tint, or when, at the place in question, the hair becomes loose, then the irradiation of this part must be stopped.* This occurs after from seventeen to twenty-five sittings, with hypertrichosis, and after seven to ten sittings with sycosis and favus.

"In a case of general growth of hair on the face, it is of advantage to treat both cheeks at the same time, and after these have been depilated, to treat the chin. Occasionally, there are disagreeable occurrences, such as slight conjunctivitis, pruritus, and erythema. Conjunctivitis may be avoided by the use of lead masks, or by advising the patient to close the eyes during the sittings. For treatment of the conjunctivitis the usual astringent eye-wash proves effective. For the erythema and itching the fifteen per cent. boric lanoline acted on all occasions as an excellent remedy. Both of these symptoms, as well as conjunctivitis and the slight bronzing of the skin to which many women are averse, disappear spontaneously in two or three days. In the case of lupus the irritation may be more intense, and one need not be afraid of the appearance of slight dermatitis. As we have already stated the affection proceeds by imperceptible stages toward cicatrization. The scars, moreover, are very tender, and resemble the normal skin. Quite striking, too, is the improvement that takes place under this treatment in the *complexion* disfigured by scars, pustules, and comedones, and this may be due to the circumstance that in the uppermost layers of the skin a small exudation stretches the epidermis, and therefore removes elevations and depressions.

"With this treatment, however, the cure is not yet completed. Hypertrichosis, especially, still needs for its radical removal a long after-treatment, consisting of three to five short sittings at intervals of from four to eight weeks for about a year. Should this after-treatment be neglected, the hair at the depilated places will, in by far the majority of cases, begin to grow again in about two and a half months. Only in a few cases did the first course of treatment suffice to accomplish a radical cure. I would here call attention to the fact that the results of the ingenious Finsen Method of treatment by rays of light correspond to those obtained with X-rays, as regards lupus. It should be noted, however, that the Finsen treatment seems suitable only for smaller lupus patches, whereas the X-ray is preferable for large areas."

Small currents were used by these authors. The direct current used to excite the primary of the coil was usually twelve volts and one and one-half amperes. They attributed the absence of all accidents and ill effects during treatment to the use of these relatively small currents. Trials made in a large number of patients justify the statement that henceforth a radical cure of the above-mentioned diseases can be assured. The cure of favus and sycosis requires but a few weeks, while hypertrichosis requires a very long period. The duration of the treatment of lupus depends upon the extent of the disease. A large number of modifications which the skin undergoes during the influence of the rays are due to the effect of the rays on the vascular system of the skin as Kaposi has stated. It is now certain that in treating skin diseases with X-rays the silent discharges of the high-tension current play a considerable part. Freund has studied the physiological effect of direct sparks, silent discharges, and other invisible radiations, and arrived at the following conclusions:

"Direct sparks, whatever be their origin—whether direct discharges from an induction coil, or silent discharges from the d'Arsonval-Oudin high-frequency apparatus may cause the hairs of animals to fall out. Direct sparks can destroy both recent and full-grown cultures of bacteria or arrest their growth. Experiments have been made on staphylococcus, pyogenes aureus, bacillus typhosus, those of diphtheria, anthrax, tuberculosis, the fungus of Soor, and the achorion of Schönlein. This action of direct sparks is increased by grounding the patient, by bringing the electrode near, by more rapid interruptions, and by increasing the primary current. These effects are produced even through thin layers of wood, paper, aluminum, tin-foil, and skin. The action is extended to micro-organisms suspended in liquids. Negative discharges produce greater physiological effects than positive, but over a smaller area. According to these experiments the X-rays have no physiological importance apart from electrical action.

"Pathological effects produced in the skin by direct electric discharges consist of alterations in the vascular system, irritation, inflammation, and hemorrhages into the dermis. In the discussion M. Oudin recalled the experiments performed at St. Lazare on the action of X-rays on the nutrition of hairs, and pointed out the great difference he has observed in different subjects under the same experimental condition. In the clinical cases of M. Bernard epilation was produced under the hole in the sheet of aluminum, but not under the sheet itself. M. Restot was of the opinion that the effects attributed to X-rays on the vasomotor system must be referred to an action on the peripheral nerves. M. Bouchacourt said that, whenever he observed accidents or sensations in the numerous experiments with which, since the discovery of X-rays he had been ceaselessly occupied, he has attributed them not to the rays themselves, but to purely electrical emanations proceeding from the apparatus. M. Bergonie remarked that, so far as his own experience went, whenever he used a tube of low resistance around which no electrostatic field was produced he has never produced either accidents to the skin or falling of the hairs in spite of long exposures. On the other hand, with a high-resistance tube from which there was a discharge to the surrounding objects, and, therefore, also to the patient, he has observed slight erythema, and the efficiency of the tube is also diminished for radiographic and fluoroscopic work. '*A tube which will make a good radiograph with marked contrasts does not injure the skin however long the exposure,* whereas a discharge which produces a bad radiograph with poor contrasts gives rise to more or less marked alterations of the skin.*'

"In closing, M. Schiff stated that the action upon hairs depends upon the duration and intensity of exposures. Aluminum had not appeared to him a sufficiently protective metal, while leaden masks have given him complete satisfaction. Lastly, he agrees with all who think that the curative actions he has observed are due not to

* This statement must be restricted by readers to refer to skilled regulation of distance and normal time, for it is absolutely certain that exposures at too close range and for a duration beyond safe therapeutics can cause dermatitis even with such a tube, or any tube. Distance and dosage of current must be properly regulated as well as exposure-time.—AUTHOR.

the rays themselves, but to the electrical conditions that accompany their production."

In a note on the X-rays as a curative agent in certain diseases of the skin Williams states it is his experience that it is *not necessary to produce an inflammatory reaction.* This is also his opinion in the treatment of lupus, in cases of which he "has demonstrated the accuracy of this conclusion." Dermatologists may read the next excerpt with care.

"The problem of utilizing these properties of X-rays for therapeutic purposes has involved not only the determination of the effects of X-rays upon tissues of various sorts, healthy and diseased, but the determination of the conditions under which the desired results might be attained within the limits of safety. A number of experimenters have engaged in clearing up these questions. The results which have been attained by various workers in establishing the conditions of safety of the use of X-rays for diagnostic purposes have furnished many of the data which have been utilized in working out the problems of the use of X-rays for therapeutic purposes. The advantages which this method seems to offer for the treatment of lupus may be briefly summarized as follows:

"1. Efficacy: Practically all of the cases which have been treated by this method have been of grave, persistent character, and had resisted recognized forms of treatment for years. The diagnosis in practically all of the cases is above question.

"2. Freedom from pain: When one remembers the various other plans of treatment, with the never-ending repetition of painful procedures in the severe cases, such as those in which this method has been used, the fact that this method is practically painless appears as an advantage of no small consideration.

"3. The character of the scars: All observers agree upon the excellent character of the scars following this method of treatment. They are soft, pliable, and thin, and nearly approach the normal skin in appearance.

"The removal of hair by this method is attended by no disagreeable sensations and by no accompanying symptoms beyond at times a slight erythema or pigmentation, lasting a short time. The skin, after removal of the hair, is left in the same condition as before, except for the absence of hair. There seems every reason to believe that in X-rays we have an agent of the utmost value for the removal of hair. It is painless, not nearly so tedious as electrolysis, and can be applied to the hairs of a large surface at one time. When there are only a few large hairs to be removed electrolysis will still be probably the more convenient method, but there is no comparison in convenience between the two methods for taking off a large number of hairs from any given area. For instance, all of the hairs from the back of the forearm can be removed together. The method is particularly adapted to cases in which it is desired to remove down and profuse growth of hair.

"The mycotic diseases of the hair and hair follicles, such as tinea tonsurans, favus, and sycosis are among the most intractable diseases that the dermatologist is called upon to treat. The difficulty is in getting at the peccant organisms. In practically all methods of treatment of these affections the first essential is thorough epilation. But thorough epilation is easier said than done, for, leaving out of consideration the pain and tediousness of it, the difficulty of epilation by mechanical means is that in the diseases where it is indicated the hairs become fragile, or so macerated and weak that in the attempts at epilation they break off, leaving in the follicles the diseased bulbs and broken hair shafts, filled with the organisms almost out of reach of one's remedies. In the treatment with X-rays this difficulty seems to be overcome in an ideal way. The hairs become loose and are removable without force. It is probable too that the effects of X-rays are not limited to their depilatory properties. In sycosis in particular the method has proven successful.

"It is conceivable that this method could be applied in all conditions where epilation is needed. It has been applied with success by Gocht, in wounds of the scalp in which healing was prevented by growth of hair into the wounds. It has not, so far as I know, been applied for the removal of hairs in trichiasis or for the removal of hairs for any purpose about the eyelids." (PUSEY.)

Especially interesting are the following observations of recent date:

"The hard tube, I think, offers the best results. We get a steady stream of rays and an excellent result if the exposure is not too long. If it is too long you will probably get a sore. A lady who came from Germany showed me her arm, which had been exposed for half-hours daily for a month. It had a sore which had not healed for two months, and had left the tissues hard. With regard to different diseases I have the pleasure of bringing some of my cases here to-night. Two of them were examples of very bad rodent ulcer. I commenced treatment on one of them about June 18th. The ulcer at that time extended over the forehead into the corner of the eye. He has had twenty-five applications of fourteen minutes each at irregular intervals, with the result you see to-night, and I think it is sufficiently encouraging for me to go on. In the course of twenty-five years' practice I have never seen anything which has given such capital results in so short a period. The other case, in which there was an ulcer all over the top of the head, has equally improved. He has not been regularly treated, but results are going on equally well. In my third case the disease appears to have dried up.

"I have been making several experiments on ringworm and alopecia. I had a very bad case of alopecia in which I made one exposure of fifteen minutes. The next time the patient came the patch was larger and looked worse. In about two weeks more he came back, and his hair was growing beautifully." (Dr. Startin.)

"So far as I can judge Dr. Sharpe considers treatment for certain skin diseases with X-rays and high-frequency currents about the same. Personally, I get more success, and, with shorter treatment, by using high-frequency currents, not only locally, but generally. With regard to the disputed action of X-rays or high-frequency on bacteria I may say that you cannot kill them directly, *but you can grow them to death.* When they get to the fifteenth or the sixteenth generation, they are not worth calling bacteria—they have grown themselves out of existence." (Dr. Chisholm Williams.)

"I agree with the contention that the therapeutic effects of X-rays in various skin diseases *are best attained without dermatitis.* At the London Hospital some thousands of applications of X-rays have been made in cases of rodent ulcer and lupus during the last eighteen months without the occurrence of a single case of dermatitis. *Hard tubes* alone were used. Dr. Sharpe has compared the effects of X-rays upon the skin with those produced by the chemical rays of light with Finsen's apparatus, and suggested that the same agent was at work. I cannot agree with this, as the effects are so very different. Those of the chemical light rays are seen in from six to twelve hours after the exposure. The skin becomes red and swollen, and sometimes vesicles form. These heal with great rapidity under a simple dressing. Again, there is no doubt that the chemical rays possess very active germicidal properties, while the evidence in favor of such properties in X-rays is very conflicting." (Dr. Sequira.)

"I find rodent ulcer much more amenable to the X-rays than lupus, and have had some remarkable results. They have all been bad cases of advanced disease. In some the Finsen method had been tried and had done little good, chiefly, perhaps, owing to the difficulty of applying the compressors. My method of treatment is always the same. I work with a tube taking a spark of about six inches, the anode about six inches from the face, and the exciting current about six amperes. The face is covered, except the diseased portion, with a mask made of an old handkerchief covered with lead-foil. Treatment goes on steadily day by day, ten minutes at a time. *I have not had any reaction troubles.* The one lupus case which I have treated seemed to do best when exposed seven or eight times to a low-resistance tube, after which a slight reaction occurred. With fairly high tubes we went on without any reaction." (Dr. Low.)

"*A consideration of the effects* of X-rays upon tissues does not leave us altogether in the dark as to the reason for these results. The condition of tissues affected by X-rays has been studied histologically by several observers; among others by Gilchrist and Kibbe in cases of X-ray dermatitis, and by Oudin, Barthelèmy and Darier, in X-ray baldness. These observers agree that the most marked changes are found in the epithelial structures. The growth of the epidermis is influenced in a remarkable way. There is great increase in the thickness of all of the layers of the epidermis, particularly of the mucous layer, increase in the amount of keratohyaline and pigment, and evidences of greatly increased karyokinetic activity, all going to show that there is marked stimulation of the activity of cells. The studies made by Oudin, Barthelèmy, and Darier—in which the histologic studies were presumably made by Darier—were made upon guinea-pigs in which baldness *without dermatitis* had been produced; and the findings are particularly interesting. Histologically the tissues showed:

"1. Enormous thickening of the epidermis in all its layers.

"2. Atrophy of the hair follicles, which in places had entirely disappeared.

"They conclude: 'The thickening of the epidermis in all of its layers, the increase of keratohyaline, and the quite extraordinary atrophy of the follicles may be viewed as a reaction against an irritant of unusual strength. This irritant appears to increase the vitality of the least differentiated skin elements while the differentiated elements, hair, nails, and glands undergo retrogressive changes and atrophy. Of the hair follicles only traces remain, one or at most three in a microscopic field, and these are no longer follicles, but only conical prolongations of epidermis which dip down seemingly only half so deep as normal follicles. Of hair papilla, or regeneration bulb, every trace is lacking.' *Bearing these observations in mind the statement that permanent removal of hair may be caused by exposure to X-rays loses some of its startling character.*

"The changes in the corium are those of an ordinary inflammatory process without peculiar features—to quote Kibbe: 'Capillary dilatation, with collection of round cells scattered through its (the corium's) structure, particularly around the hair follicles.' There is, therefore, little suggestive of the explanation of the effects of X-rays upon diseased conditions of the connective-tissue structures of the skin, in the histology of X-ray dermatitis, as far as it has been studied. An analysis of the clinical phenomena does, however, throw some light on the subject. In the first place, as regards the hair follicles, Kibbe has made the interesting observation, which I am able to confirm as regards X-ray erythemas, that in the development of an X-ray dermatitis the erythema is seen, under a hand lens, to develop first as a 'punctate redness due to hyperæmia around the hair follicles.' In sycosis under treatment with X-rays, inflammation first shows around the hair-follicles, and, I may add, if the exposures are rightly managed, the inflammation may be confined to the perifollicular tissue. In other words, the hair-follicles and their connective-tissue envelopes are particularly sensitive and react first to the irritation of X-rays. This is more than ever the case if the follicles are already the seat of disease. To this extent, and to this extent only, X-rays may be said to have a selective action on the hair-follicles in inflammatory affections, like sycosis and tinea tonsurans.

"Much the same may be said in regard to its effect in lupus. If a patch of lupus is put under the influence of X-ray exposures the lupus nodules become reddened and inflamed before, or even without the surrounding healthy tissues being affected at any time. Foci of disease so small as to be imperceptible before treatment become inflamed, redden up, and become visible. If the exposures are persisted in, the lupus nodules will break down and be destroyed before the surrounding tissue is severely affected. In other words, the specific tissue of the lupus nodules is *of such low vitality that the influence of X-rays may cause its absorption or even destruction before having any considerable effect upon healthy tissue.* And thus far the rays may be said to have a selective action on lupus.

"The practical problem which has to be solved in applying X-rays to the treatment of skin diseases is to so manage the rays as to attain effects sufficient for therapeutic purposes, without overstepping the limits of safety and producing undesirable results. This problem is easier now than it would have appeared three years ago. The evidences that the exposures have been carried far enough are: The appearance of erythema or pigmentation. Blanching of the hair. Loosening of the hair. In the treatment of hypertrichosis the method is pursued with great caution to avoid irritation. In the treatment of inflammatory affections less care is taken. It is not found necessary in the treatment of any of the diseases to carry the irritation to a painful degree." (Pusey.)

Action of X-Rays.—At first many deemed an inflammatory reaction requisite for curative action, but it soon became evident that if irritation was the curative factor we have simpler means of setting it up. Men without adequate experience with related agents have written theories, and have laid down rules that will perplex the novice for some years—till they happily get out of print. But enlightened experience has now settled, at least empirically, the present view of the case as follows:

A dosage rich in rays is desirable. The tube is a vacuum electrode related to those becoming familiar with High-Frequency therapeutics. The best dosage of X-rays is obtained when a fat electric current excites a tube which is neither low nor high, but within the range of medium vacuum which will best develop the bombardment of the given current and transform it into the most abundant quantity of rays. The therapeutic action of this electrical discharge is allied in nature to that of the ultra-violet field of electric-light, to the similar spray from a large Static machine with a suitable electrode, and to the High-Frequency spray—all products of electricity and all producing similar effects in skilled hands. Men acquainted with but one of these discharges may be surprised at their similarity.

The curative action of a substitutive inflammation in certain cases is not denied, but it is denied by the best authorities that *dermatitis* is *X-ray therapy.* The true curative effects of X-rays are obtained in all cases without the need of setting up any dermatitis, and, if the latter occurs, it is a fault of method and a drawback rather than a help. Some still cling to the older opinion, but the fact that leaders get better results without dermatitis proves their case.

Given an *efficient* electric current and tube, it matters not what *type* the current may be. An alternating, direct, or Static machine current will do the work if the accessories are suited. Some have asserted the need of small currents with coils, but later experience proves that if the tube and technic is adapted to the work a large current is vastly more efficient and shortens the treatment more than half, without ill-effects that were formerly feared. The present tendency is to look for shorter exposures and quicker results through the aid of increased efficiency in radiance—larger currents and the avoidance of low, and hence feeble, tubes. Large and well-equipped Static machines giving thick currents are particularly suited to X-ray therapy. There are several thousand Static machines in use in X-ray treatment as well as in X-ray diagnosis, and many claim superiority for them. The author does not wish to take a partisan side, and he is well aware that many Static machines are too small in size to produce an efficient current that would satisfy the trained expert, but, granted an energetic and well-made machine giving the thick current that only sixteen to twenty-four revolving plates of thirty or more inches in diameter can generate, the facts are as follows:

1. The greater the quantity of light the better, and the maximum produced under skilled control is *perfectly safe for the tissues at a proper distance.*

2. It is exceedingly easy to avoid dermatitis with tubes excited by static currents. With fair precautions they are safe. Avoid too long exposures at too short a distance.

3. It is well-known that static electricity is least liable to dangerous accidents either to patients or to apparatus.

4. Its *remarkable adjustability* permits complete dose regulation to suit any state of the tissues. A medium tube can be run up and down the widest possible range of radiance. It is the most flexible current known, as respects manipulation of X-ray tubes—granted skill on the part of the operator.

5. The author's X-ray gauge furnishes the means of definite measurement of the radiance and meets the objections of those who judge a Static machine by the mechanism of a coil.

6. Much of the best work in all kinds of X-ray therapeutics has been done with the Static machine, as reports show.

During the past five years the author has been many times misquoted in respect to "burns" from Static machines. Many have appeared to find delight in pointing out his supposed error in stating that a static current will never cause an X-ray burn. But he never said so. None of his writings say so. Before our first book was in press there were reports of burns by Static machines and we were aware of them. All who quote me omit my *qualifying remark* that the Static machine in exposures for radiographic work will not burn if a properly dosed current and a proper radiographic method are employed. This has been our view in the past and is still the fact. Abuse is possible, and alterations of the direct static current can transform it so as to be removed from within our proviso, but it is certain that we can regulate the current and tube and adjust the technic for a radiograph so safely that the patient would not be burned even by "nightfall of a long summer's day." Those who pervert these facts assume that there is no difference between a method which seeks to *avoid* ill-effects and one which *invites* them. Not a single statement of ours in the past can be better demonstrated to-day than what we have said about X-ray burns and static electricity. But we have not said some things which have been alleged. What we have written on the subject is capable of *demonstration*, and no one has yet confronted us with disproof, while, on the contrary, we have repeatedly demonstrated the accuracy of our statements to students.

The action of the rays on the tissues is *cumulative* if treatments follow each other before effects subside, and this is desired up to the point of sufficient therapeutic action. Beyond this point control and limitation of effect simply requires stopping the treatment till results mature. Therefore, the interval between treatments is an important factor in the dosage. With a tube excited by a fat current and yielding a rich stream of X-rays, about all the present therapeutic demands for the treatment of practically all lesions are met by a single technic and simple principles of dose regulation. These are about as follows:

1. Protect the surrounding field so that the rays will reach only the diseased tissues.

2. Clear away any possible hindrance to the free penetration of the rays as they do not exert active therapeutic energy through much resistance. Use no opaque dusting powders on the lesion while applying X-rays. The production of a local anæmia assists action, but is seldom necessary.

3. Place the diseased field square with the path of the rays and

centre the focus the same as for a correct radiograph. The main action is in the axis of the rays. Slanting rays are less effective. The sun's rays act in the same manner, as all know who compare early morning rays with vertical rays in summer.

4. Place the tube so that the wall is four to six inches from the surface of the tissues. With modern large tubes from five to eight inches in diameter this removes the anode of the tube about ten inches from the skin, and this is safe under proper dosage.

5. Begin with an exposure of five minutes daily for three days, for a single area. If more than one area requires treatment pose separately and expose each five minutes. Do not forget to connect a grounding wire to the metallic shield used to protect the normal tissues from the rays. After three treatments continue three times a week until some effect of over-action suggests a temporary stop, or till sufficient curative action has been accomplished to suggest an interval to let the results mature before further treatment. In either case resume exposures as indicated, and, after again watching effects, again stop when it seems wise. In this way conduct the case to a termination in recovery, or the nearest possible approach to it. After some experience with the given case the tolerance of the tissues will be ascertained, and exposure-time can be increased as judgment indicates. For all but the trained expert a limit of ten minutes may be adopted as a prudent duration of treatment with efficient apparatus. This is equal to more than a half-hour of early methods with low tubes.

6. The first sign of irritation from X-rays is much like the first sign of sun-burn. The skin shows a little redness and heat or itching. Whenever this is noticed stop treatment till it subsides, which takes but a few days if there has been no improper excess of treatment. The slow-healing, deep injuries of the era of unregulated dosage and wild methods do not belong to X-ray therapy as taught by the present author, and need not be considered here. No careful student of this work will ever see them again. The bicarbonate of soda solution or emollient ointments mentioned under "burns" will quickly correct the mild erythema that is our warning to halt in rational treatment. A cooling sedative static breeze with positive insulation is remarkably effective in incipient irritation.

7. The next important point is how long to continue treatment. In all lesions liable to a relapse do not stop with the healing over of the surface, or, in a case of depilation, with the first falling out of the hair. Recurrences have been the result of too early cessation of treatment. Be governed by the observed effects till surface indi-

cations seem to have been met, but to give permanency to the results give such further treatment at increasing intervals as the history of cases in the hands of experts shows is necessary to prevent relapse. This varies according to the nature of the lesion, but ordinary medical judgment will guide the operator to whom the principles as above are explained. Read carefully the reports of others and note results.

8. Assist results in every case by such adjunct treatment as may be suggested by special indications. Not only drugs, surgical methods, and, in certain cases (as large external cancers) a preliminary operation, may be required by patients in co-operation with X-rays, but we also have in the great resources of modern scientific electro-therapeutics a means of efficiently helping the rays. Do not forget this. Every X-ray operator should read up the whole subject of medical electricity.

9. Do not begin with one tube and use it continuously with a series of cases. Long daily tax upon it will soon increase its resistance too much. Have at least three tubes and use them in rotation. This gives each of them a rest, and with care such tubes will last an exceedingly long time. Also make it a rule to run a tube with just enough current, but never more than is needed in work. No other tax cuts down the life of a tube so much as an excess of current. Many neglect this simple precaution. When much work is done an increased number of tubes to permit rotation and rest is an economy.

In discussing tubes for X-ray therapy—and there has been much undigested controversy as between "hard" and "soft" tubes—the author of a large treatise, published in 1901, stated: "There is no wholly satisfactory way known at present of measuring the intensity and quality of light obtained by one physician with one apparatus, as compared with that obtained by another with a different apparatus. It seems advisable to call attention to the inadequacy of the data given by various writers, as otherwise it might appear incomprehensible that the same results do not follow when apparently the same quality of apparatus was used." It seems to me that my Penetration Gauge described in this volume serves the purpose, and will report a measurement which covers intensity and quality in such a way that all varieties of electrical apparatus are at once brought to a common gauge. Having been using the principle in instructing students since September, 1896, I hardly think there is any doubt about the validity of my gauge as a true measure of X-radiance, such as other authors regularly say is "not known." Those who test the gauge regard it as demonstrating its efficiency.

To complete the instruction contained in the foregoing items of world-wide observation during the experimental period of X-ray therapeutics we cannot do better than review in orderly survey the striking features of this remarkable development. We cease to wonder at work we daily see, but if we put back the materia medica six years and then consider how we shall accomplish some of the results now granted to patients by electrical X-ray discharges we promptly confront a barrier that in important spots proves insurmountable. As time matures our electrical technics appreciation of the scientific therapy which is destined to be built upon the empirical foundations here recorded will spread throughout the profession till all practitioners seize its benefits. To the following chapter especial attention is invited.

CHAPTER XXXVIII

X-RAY THERAPY IN SKIN DISEASES

A Chapter of Wide Scope for Careful Study. A Valuable Resumé of Experience with Cases and Methods. Hints from Practice.

Of more than 200 important X-ray monographs prior to this date a large number have reported upon the actions and results of this agent in cutaneous medicine. An increasing value is recognized. Technics improve. Dosage is better regulated. Certainty is replacing experiment. Exposures are shortened. Frequency lessened. Ill-effects are avoided. Dermatitis is proved unnecessary. Coils and Static machines when of similar current-value are equally efficient. Tubes are standardized. Methods are ready for general professional acceptance. In this important chapter we present the individual experience of an able practical worker whose labors deserve study. Without a specialist's knowledge of skin diseases, without prior experience in X-ray work, but with ten years' experience in electro-therapeutics and impressed by Kümmell's report on lupus, the first attempts of Dr. Sharpe will teach other beginners a great deal of indications and methods.*

"In February, 1899, a girl aged twenty-one was sent me who had been many years under treatment for *lupus*. She had large scars on both arms and one over the right temple where the disease had been surgically treated, and the disease was reappearing on her face. There was a patch consisting of several nodules covering the whole tip of the nose including the front of the septum; the mucous membrane of the left nostril was extensively involved, impeding the passage of air, and there was some ulceration. Inside the mouth the disease had attacked the uvula and the right faucial pillar, the hard palate, and the gums. The disease had been apparent in the nostril for three years, but had only been noticed on the skin about one year. It was not a good case for a first experience, as I did not see how I was going to get the rays anywhere near the throat, and all

* Cited with the kind permission of Rebman, Ltd., from Archives of the Roentgen Ray, London.

operators, as far as I then knew, were agreed in saying that mucous membranes were not affected by the treatment. However, the nose offered a fair field, and I started on that, adhering as closely as possible to the orthodox technique. Treatment was begun on February 22d.

" The patient was placed on her back on a couch, her face protected by a paper mask covered with tin-foil in which a hole had been cut for the nose to come through. The tube was fixed in a position over the face so that the rays should fall perpendicularly on the diseased part. The cases were taken to a laboratory where a twenty-inch coil was available, as at that time I had not got a coil in my own house. I was using a Static machine to excite my tubes, and as the therapeutic effects of rays so produced were not known to me I did not like to run any risk of failure with my first cases. *A large tube with a bulb five inches in diameter and low vacuum was used. The coil was worked at twenty volts with an average primary current of five amperes. A mercury interrupter, worked at six volts, gave 250 interruptions per minute. The anode was five inches from the patient's nose. Daily applications were made, lasting from twelve to fifteen minutes.* After the first four treatments the skin became slightly red and sore to the touch, the nodules appeared to stand out more distinctly and to insulate themselves; red scabs made their appearance, which gradually dropped, leaving a red tender-looking spot behind. This peeling process went on until at last no more scabs formed and the skin was soft and smooth. The peculiar effect of insulation of the nodules seems always to take place, and has been described by other observers; nodules show themselves which have not been apparent before. None of the nodules ulcerated, but all the area acted upon became slightly œdematous, and that and the redness remained for some time after the treatment had been stopped.

" After twenty-four applications all the nodules had disappeared, the mucous membrane of the nostril seemed perfectly healthy, and there was no obstruction to the breathing. I was agreeably surprised to get such a good result in the nostril, as all other operators had then reported complete or partial failures with mucous membranes. I next turned my attention to the throat and tried to direct the rays by means of a metal tube which the patient held in the mouth. The throat certainly got better in that the congestion greatly diminished, but the disease at the time did not appear to be seriously affected. I might have accomplished more could I have kept her longer under treatment, but her home was in the country, and I had to let her go. She was under treatment three months; not long enough to insure thoroughness of action, but *eight months later I learned that the throat and mouth were well.*

" For a short time during the treatment of this case I exposed the old scar on the temple to the influence of the tube, and it improved in appearance to a remarkable degree. It became more vascular, the skin softer and moister, and it was altogether much less noticeable.

PLATE 161.—Knee. "Mr. H., age fifty-five, Rheumatic Diathesis. Repoıt of similar case treated eight months ago encouraged me to experiment with the Rays in this sort of condition. Patient is practically well. Whether due to the influence of the Rays or to the dietary conditions imposed upon him, am unable to say. He believes it to be the former." The valuable Instruction Plates teaching methods of X-ray Therapy and marked in this section with the name (Blackmarr), were photographed especially for this work by Dr. F. H. Blackmarr of Chicago, whose note accompanying them contained the following line: "This work, the X-ray treatment of pathological conditions, was begun by me somewhat over three years ago, and although I have met with many discouragements I am thoroughly satisfied that the X-ray will become one of our most positive therapeutic agents." Our limited marginal space has prevented inserting the doctor's full description in some of the cases.

PLATE 162.—"Tubercular Knee-Joint. This went through the ordinary palliative treatment, etc., in the hands of one of our best Chicago surgeons, and amputation was advised. X-ray treatment lasted from April 19 to June 19, 1901, result satisfactory. Patient uses limb as easily and readily as one never having suffered. Position of tube shown in photograph, and position of large mask demonstrate method. Tube used, medium vacuum, twenty minutes to ten minutes daily exposure" (Blackmarr).

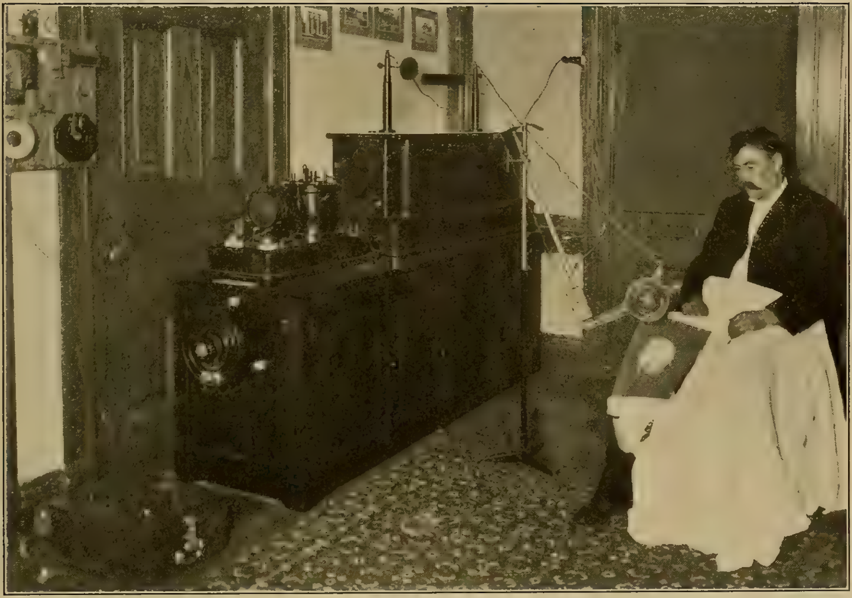


PLATE 163.—"Tubercular Knee-Joint. Photograph demonstrates method of treatment. Sheet-lead mask used; treatment lasted a period of two months. Very severe burns resulted; knee-joint improved to such an extent that patient can move joint. Two months have passed; reason for non-recovery of patient from burn is the general atonic condition of patient." Case treated by Dr. F. H. Blackmarr, Chicago, Ill., and photographed especially for this book.

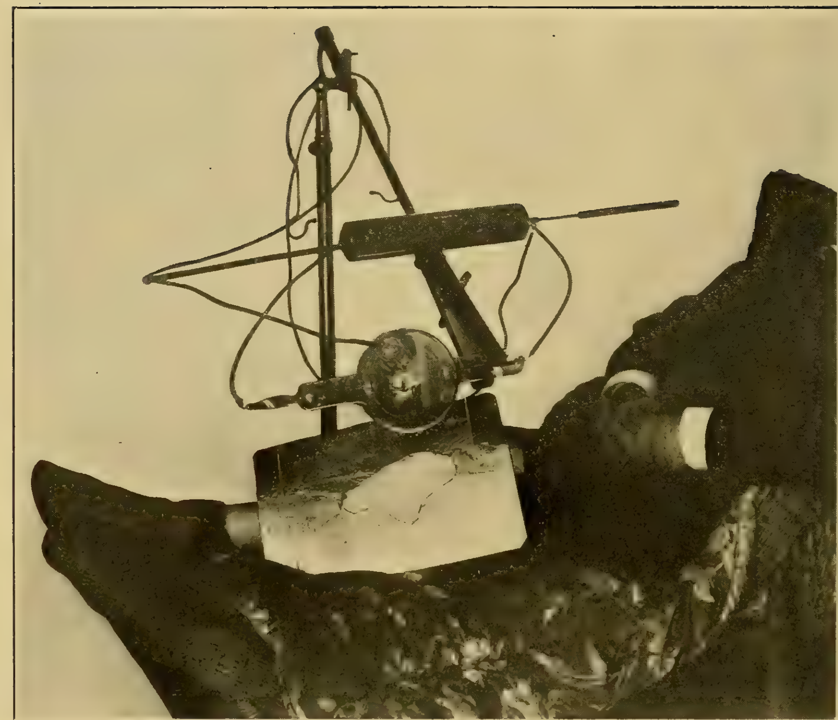


PLATE 164.—Raying a case of psoriasis, or ulcer on leg. This Instruction Plate shows a foil-covered card-board cut to fit the margins of a patch of psoriasis. A thin layer of surgical cotton is placed over the patch, and the shield is then tied on the leg with two strings. The patient rests easily on a couch. The tube is seen connected with the Bario-Vacuum Automatic Regulator, and correctly adjusted over the lesion, but for convenience of photographing the wires are disconnected from the electrical apparatus. In treatment start the tube into action, and regulate the dosage by pulling out the rod seen at the right of the cut.

A second case of lupus under treatment at the same time presented interesting contrasts. The disease in this case was confined to a circumscribed area on the wrist about the size of a five-shilling piece, covered with dry scabs. It had been growing for two years, had occasionally ulcerated, and had been treated at intervals with ointments and lotions. The patient had suffered from bone necrosis of the corresponding hand. Applications were made twice daily, but otherwise the method was the same as in the preceding case. I used a sheet of lead with a hole cut in it for a protector. The hole was *too big*, and after eleven treatments a patch of brown discoloration appeared beyond the diseased area, which got sore, and required a discontinuance of the treatment for three days. After another thirteen treatments it broke out again, and I again had to stop. By this time several of the scabs had come off and the patch was looking very well, but the patient, contrary to orders, applied water-dressing to sooth the surrounding inflammation, and the general effect was discouraging to me, so that after thirty-one applications I sent her home with orders to return as soon as the surrounding inflammation had subsided. This was accomplished in about three weeks, but she never came back *because the lupus disappeared without any further treatment.*

" Six months later I heard from her physician, who reported that it had been slowly healing all the time. The only difference in the treatment of the two cases was that one was done *twice* a day and the other *once.* Some of the German operators have always made the applications twice daily, and I should have done the same in the first case had it not been too inconvenient for the patient. The dermatitis was probably due to my carelessness in making the hole in the lead protector too large. I am still in favor of treating lupus cases twice a day when possible, especially when time is of importance to the patient. The little extra soreness is compensated for by the gain in time. My second case got thirty-one applications between March 3d and March 27th.

" So far my experience with the action of X-rays on lupus corresponds exactly with that of my Continental predecessors in the field; and, indeed, what struck me most when studying the literature of the subject was *the extraordinary similarity of process and results that they all got.* There was among Kümmull's cases one which did not yield to treatment—a boy suffering from what had been considered lupus of the face. Two weeks' treatment produced no effect whatever, so it was given up. Later it was found that the boy was suffering from syphilis, and he got rapidly well under specific treatment. Two French physicians reported a case of supposed lupus in which X-rays had no effect, and in these there was also a history of syphilis.

" Among all the operators Professor Schiff seems to have been the most successful in *avoiding dermatitis.* In fact his first experiments, which were made on *epilation* cases, were undertaken for the purpose of showing that *the dermatitis was not a factor in the thera-*

peutic process, a point which at that time was held in question. His observations are especially valuable. When he wished the action to be very slow and gradual, as for epilation, he used low currents, tubes of low intensity, gave short exposures, and kept the tube further away. What he calls the intensity of the tube he measured by the distance at which it would show the bones of the hand on a screen. This varied from six inches to three feet. The voltage of the current varied from ten to thirteen, the primary amperage from one to three, the time of exposure from ten minutes to twenty-five minutes, and the distance of the tube from four inches to ten inches. Schonberg later published the reports of nine cases, all successful, using higher voltage and amperage, and most of his cases got dermatitis.

"My Static machine has twelve twenty-four-inch revolving plates. A high-vacuum tube gives beautiful screen effects. I was assured that it would not be good for therapeutic purposes, but I determined to *try*. I did my first case of *hypertrichosis* with it. It was very slow, but the result was excellent in the long run. There was no inflammation; a good deal of brown staining which remained long after the hairs had come out; and the skin felt a little bit sore and stiff.* The hairs all lost their color before they came out. The case had thirty applications, but ten days were lost in the middle of the treatment by lack of experience on my part. Instead of using a mask, as I usually did, to protect the face I simply laid sheets of tin-foil over the face with nothing between them and the skin. The result was that she got a sort of erythematous eruption over both cheeks with slight swelling and a great deal of heat and soreness; her eyes were suffused and some of her eyebrows came out. *The part of the face that had been left uncovered was not affected.* She recovered in ten days. After that I always used a mask and it did not happen again.

"A few days afterward exactly the same thing happened with another case when I was using the *coil*. I had left off the mask and covered one side of the face with tin-foil, and in a few days a patient complained of her cheek being sore, and I saw exactly a repetition of the first case. I stopped at once, giving the face a day's rest, and it was all right by the following day. I took the warning and have never since worked without a mask lifted from metallic contact with the skin.† (See Plate No. 173.)

"The course of this depilation case treated with the Static machine exactly corresponds to the description given by Schiff of his first coil cases as to the length of time, the brown discoloration, the *de*coloration of the hairs, and their *disappearance without the slightest sign of in-*

* The negative static breeze on the bare skin relieves this condition beautifully. (S. H. M.)

† The direct irritant action described above (which passes into inflammation and will produce an ulcer if continued long enough) is caused by the short electrical spark-discharge between the charged metal and the *dry* skin, and is easily avoided by either perfect electrical contact or by placing the metal so far from the skin that the well-known "static effect" will not take place. Although the author of the above article "does not understand the action" it is one of the familiar phenomenon in connection with electricity, and has been remarked for over 200 years.—AUTHOR.

flammation. In fact until the hairs actually came out, the patient refused to believe that anything at all was taking place. He says, and I have found it to be so, that there is *much less chance of recurrence after this process*, and that it causes atrophy of the hair-roots and not inflammation. The only drawback is the patient's scepticism. They cannot believe that anything is going on when there is nothing to be seen or felt, and for that reason I generally adopt the more rapid method with thicker currents. Even with the coil treatment patients vary much. Where one would be quite sore after eight applications another will feel nothing even after twelve or even more. For instance, I have a case under treatment now with the coil. She had thirteen applications in three weeks before she felt anything at all. Then she felt sore and stiff, as though the skin were stretched. Now the hairs are coming out and she is reassured, but she was very discouraged at first because she thought that nothing was happening.

"The next case treated with my Static machine was an *eczema.* I used the same tube as in the previous case. The eczema was a small patch on the hand. It had appeared after a burn three years ago. I treated it *eleven times, from fifteen to twenty minutes, with the tube six inches distant*, carefully protecting the rest of the hand. It simply faded away, getting paler and paler each time. *There was no inflammation or soreness.* At the present time you could not tell which hand it had been on. This is the only experience I have had with the influence of X-rays on eczema, and it is not a very good one, as the diagnosis is open to criticism, but the fact remains that it was healed without the slightest sign of inflammatory reaction. Hahn reported success in three cases of chronic *eczema* in July, 1898. The disease disappeared rapidly after ten to sixteen applications in all three cases, and only in one was there any inflammatory reaction. He used the coil and made applications daily of twenty to twenty-five minutes with the tube twelve to fifteen inches away. *In my case the tube was not more than five or six inches away. The process was as rapid with my apparatus as with his.*

"This rapid action has also been strikingly illustrated in another case, viz.: *psoriasis.* In Germany psoriasis is considered a parasitic disease, and was therefore held to offer a good field for the action of the rays. The patient had the disease for twenty-five years, and had tried every treatment that had been devised for it. In places it was in isolated patches, but in other places there were large areas where you could see no skin at all. I began on a small patch which I rayed through an opening in a sheet of lead with the tube and current the same as in the case of eczema. The effect was exactly the same, *the spots fading away without the slightest sign of inflammatory action.* The brown pigmentation appeared, at first in the healthy skin on the margin of the diseased area, and, as the disease disappeared, in the healthy skin that replaced it. *About twelve applications were necessary to insure the disappearance of each patch.* After the first patch treated had disappeared, and, finding that there was no danger of dermatitis, *I gave up using a protector, and I think that I have established the fact that a tube excited by a Static machine will not ordinarily produce dermatitis in this form of technique.*

"Twenty minutes a day for twelve days on the same area did not even redden the skin, but by way of an experiment I subjected one untreated area to a tube excited by a twelve-inch coil worked on the 100-volt alternating circuit with an electrolytic break. The average current passing through the primary was three amperes, and the parallel spark-length was about two inches. I began with five minutes exposures, but as nothing alarming happened I increased them to fifteen. The skin got a little sore, but the effect on the disease itself was nothing like so good as with the other tube. The case is still under treatment and likely to afford a field for study for many months yet. (See Plate No. 164.)

"I found that *at whatever stage of their development I attacked the spots they never got any further.* Those that were treated from their first appearance as tiny pimples never grew at all, and those that were already ripe gradually faded away, and not as they normally do by healing from the middle outwards. Again, I found that many of the spots after about six applications, if left to themselves, disappeared without any further treatment, but I also found that they came back again, while those that I treated *continuously until they disappeared* did not come back. The same thing may happen with *lupus.* The explanation is probably this: The rays have a healing or revitalizing effect on the inflamed tissues enabling them to combat the disease of which they are the outward and visible signs, but the disease itself is not affected at this stage. That does not take place till later, for most of the efficiency of the rays will be absorbed in the hyperæmic tissues.

"I think there can be no doubt that to permanently alter the condition of the skin the rays must be conveyed to the corium, where all the energizing organs reside, and where the parasite—if there be one —is to be found. If you set up a superficial hyperæmia before this has been accomplished, it forms a sort of defence of the deeper layers and you defeat your object. If you have a ready-made hyperæmia to deal with you must get rid of it first, and then you may hope to reach the actual seat of the disease. Similarly with regard to *the removal of hairs.* You want the action, whatever its nature may be, to take place in—and, if possible, to be confined to—the corium. If you start by exciting a superficial hyperæmia you intercept your agent before it gets to the seat of operation. The hairs may come out, but they most certainly will come back again. As an example I may mention a case that was recently described. A patient was rayed for an extensive growth of hair. I think she got something like eleven hours' treatment in fifteen days. Intense inflammation was set up, going on to ulceration, but the hairs did not even come out. The process that permanently removes the hairs is not, I am almost sure, a true inflammation. I am inclined to think that it is a tropho-neurotic one. At the time when the hairs are coming out the patients say that the skin feels stiff and numb, not so sensitive to the touch as the normal side, and the hairs, if you examine them, present the same appearance as hairs from a patch of alopecia areata.

"X-ray inflammation, according to Kaposi, does not differ pathologically from any other inflammation, but he suggests that there may be another action of the X-ray on the exudation cells, and the newly formed young cells, bringing about fatty degeneration and causing their reabsorption. This observation of Kaposi was called forth by a case of Schiff's, of *lupus erythematosus* of both cheeks. It was thought that this disease was not amenable to X-ray treatment. Schiff did not expect to succeed, and was greatly surprised to find it disappear with rapidity. In less than two months one cheek was clear of the disease. His primary current was three and one-half amperes, thirteen volts; distance of tube, four inches; length of sittings, ten to fifteen minutes. He generally used a new tube which he only describes as emitting an intense light.

"*Our knowledge of the usefulness of this form of treatment is extending every year, and preconceived views of its action have to be given up in favor of broader ones.* My own small but varied experience inclines me to think that the key to the action is still missing. How, for instance, are we to reconcile the different and exceedingly opposing actions of the X-rays which have come under my observation? There is the revitalizing action as shown in their effects on scar-tissue, there is the antiphlogistic, as when the psoriasis spots fade away; there is the inflammatory, which may go on to necrosis; and there is yet another, which I shall go into more fully presently, viz.: bactericidal. I must also mention the analgesic action. Dr. Gocht treated in this way and speedily cured a case of trigeminal neuralgia of several years standing. He also removed the pain in two cases of mammary cancer. Is one agent to be held accountable for them all, or is there more than one acting simultaneously? Are the different results obtained from different apparatus to be accounted for by the varying co-relation of these agents in each case?

"Interesting to consider in this relation are the experiments of Professor Finsen with sunlight and electric-light. In 1893 he proposed a new treatment for small-pox, which consisted in placing the patient in a room from which the chemical rays of the solar spectrum were excluded by means of red glass. The result was that the development of the spots was arrested. There was no suppuration, no scar, and no secondary fever. The exclusion of the chemical rays appeared not only to protect the skin from harm, but at the same time enabled it to be exposed to the beneficial action of the other rays. For years he continued his researches into the irritating and destructive influence of chemical rays, and about three years ago established some points of similarity between them and the X-ray, and they are both potent to cure lupus vulgaris and other parasitic diseases of the skin. For these purposes he now uses concentrated electric-light, eliminating as far as possible all except the chemical rays.

"Still nearer in similarity to the X-rays, both physically and therapeutically, are the rays emitted from an electrified point by a high-potential current. A metal point connected with the pole of a Static machine, especially the negative hole, produces them in great abundance.* They will affect a photographic plate in the dark even at a distance of a foot or more, in a few seconds, giving a well-defined shadow of any opaque substance placed between them and the plate. They are absorbed in the blood-vessels, can penetrate the skin, and provoke to activity the sweat-glands. They are antiphlogistic and analgesic, can be concentrated by lenses and are much used on the continent in the treatment of skin diseases. I have never known them to produce the slightest irritation of the skin. They provoke phosphorescence and fluorescence, will pass through white glass, but not green, yellow, or red, and substances which are transparent for X-rays are not transparent for them. They seem to possess all the properties of the ultra-violet rays of the spectrum, and their action on the organism resembles closely the action of X-ray tubes with the X-rays proper left out. Plainly, they are not X-rays.

"If then, as seems likely, the X-rays proper have not part in the therapeutic action, then must our theory that a soft tube is better than a hard, because it has not got so much penetration, be given up, and we must seek some other standard of usefulness. I used a soft tube with my lupus cases, but Schiff did not. On the other hand, I used a high vacuum tube with my Static machine till it got so high that the current refused to go through it, but *I do not see any difference in the action.* There is, however, a great difference between the action of a tube excited by *heavy* currents and *small* currents, but I do not think this difference dependent on X-rays proper. However little we may know about their nature and method of working, we can no longer doubt that we possess in the so-called X-rays a very valuable therapeutic agent. Does a skin specialist ever pass a working day without seeing in his consulting-room some one whose life is more or less spoiled by the burden of some chronic skin disease that does not endanger life but which the most skilful treatment can only temporarily relieve? At present our knowledge of this action is limited to a few of these diseases, but I feel sure that further experiments will open up a wider field of action. It is true that the treatment is long as compared with some, but if done with care it is painless. For lupus above all it has many advantages. It does not make invalids of the patients, even temporarily; it saves them from disfigurement; and even in cases where disfigurement would not much matter an operation necessitates the unpleasantness of an anæsthetic, of a period of detention in a sick-room, and of a long convalescence while the wound heals.

"As to *recurrence* I think we have every reason to be hopeful on

* See "Static Sprays" in my book on Static Electricity. (S. H. M.)

that point, especially when the treatment is continued, as I have above stated. As to the dangers in X-ray therapy they are now very small. From my own experience I should say that by strict attention to the rules of technique and by daily personal observation of the patient any serious accident may be avoided. We hear of cases in which dermatitis was set up after one sitting, and once in 2,000 cases Schonberg had such a thing happen, but if certain precautions are observed at the commencement of each case it will be prevented. No two patients ever behave alike, and you must take the measure of sensitiveness of each one. There are four details of the operation which require regulation:

"1. The distance of the tube from the skin.

"2. The length of the sitting.

"3. The strength of the current.

"4. The vacuum of the tube.

"Begin with the tube at eight inches and limit the sitting to ten minutes until you are sure that the patient is not particularly sensitive. You can then gradually lessen the distance to four inches and increase the sittings to twenty minutes or even more. As to strength of current, I believe that the *amperage* is the important factor. When we wish to increase the intensity of action we increase the *quantity of current*. The protection of the healthy parts is very important. For the face I always use a mask covered with tin-foil. I cut a hole in it corresponding to the part to be rayed. It is not, of course, necessary to cut an actual hole. It is sufficient to strip the tin-foil off the mask. But I prefer to cut a hole because it gives the patient more air, and some face-masks are hot and uncomfortable things. If you are raying a face the chest must be covered with sheets of tin-foil. For the limbs I find sheets of lead with holes cut in them convenient. At the first sign of reaction, stop the treatment for a time, unless you are perfectly certain of your ability to keep it under control, which only experience will enable you to do."

"In the early part of this year I had four cases under X-ray treatment, one psoriasis, two lupus, and one epilation. I was using a twelve-inch coil with an electrolytic break. My tube was never under six-inch spark, and toward the end had gone up to 7.5 inch spark. The cases had all been under treatment several weeks, were making satisfactory progress, and had shown no signs of dermatitis. They all showed the characteristic brown staining. When the resistance of the tube had got so high that I had difficulty in getting the current across I changed it for one with a spark length of only four inches, giving very much less green hue to the bulb and a visible stream of violet discharge from the anode. Within ten days every one of the cases had dermatitis. There can be no doubt that it was caused by the comparatively low vacuum of the tube, as the details of use were not changed in any other respect. Moreover, this same tube, with its resistance raised to 5.5 inches and no violet discharge visible, is now doing good work without any accompaniment of dermatitis. I had never before used a tube in which violet rays were visible with the green phosphorescence, and I never before had a case of dermatitis in my practice. I have been asked whether the advantages of a soft tube in treating skin affections are enough to counterbalance its dangers. Since the beginning of the year 1900, I have had opportunities of *comparing the actions of soft and hard tubes on the same subject, and my judgment is in favor of the hard tube.* This reverses my previous opinion, but is justified, I think, by my recent experience."

Second and later section of paper by Dr. Sharpe:

"Prior to the latter part of 1899 we in England were indebted for most of our knowledge on X-ray therapeutics to the labors and writings of our colleagues on the Continent, and our own practical experience was of the smallest. Now things are very different. X-ray departments have sprung up in many of our large hospitals, both general and special, and our skin specialists have introduced the treatment in their consulting rooms. Cases we have had in plenty, and a considerable measure of success has rewarded our efforts—enough, I should think, to shake the doubt of the most sceptical; but are we still open to the reproach of dealing with a little understood force? Are we agreed as to the nature of the therapeutic agent, or the nature of its action, or as to whether it is simple or complex, one or many? And then, again, there is the vexed question of dermatitis—what produces it? Can it be prevented? And is it desirable to prevent it? And so on.

"I myself have lately arrived at some very definite conclusions on these points; how long they will hold out I don't know. And, first, with regard to *dermatitis*. Until the beginning of the year 1900, I had never had a case in my own practice, and I was much puzzled to account for the immunity I enjoyed. I did everything I ought *not* to have done; I put the tube as near as possible to the skin; I gave long exposures, fifteen to twenty minutes, once and sometimes twice a day; and I did not protect the healthy parts except on the face. My house is on the alternating circuit, so I use that to excite my coil, with an electrolytic break, or else I use a Static machine. I had never used the continuous current, and I did not know any one who worked under the same conditions, so I could not compare notes; hence, I naturally began to consider that my immunity from accidents was due to the form of current. I was quite wrong, as I was soon to learn.

"For therapeutic work I always use the same tube, and continue using it till the vacuum gets too high for the current. This generally happens with my coil when the parallel spark gets to seven or eight inches. On one occasion I got a new tube which was down to a four-inch spark, gave a very good fluorescence and plenty of X-rays, but showed a very distinct *violet* stream between the electrodes in the tube. I started to use it with all my cases without the slightest thought of danger, and they all, with one exception, got dermatitis—the one that escaped being a case that was only rayed once or twice a week. I see no loop-hole of escape from the conclusion that the condition of the tube caused the dermatitis, for *nothing else was changed.* Moreover, by the time the dermatitis showed itself, which was from seven to ten days after I began using the new tube, the vacuum had gone up, the violet stream was no longer visible, and I went on using the tube, and am still using it, and *have had no more dermatitis.* This experience coincides with that of operators in the early days of radiography, when the use of low tubes and long exposures was so often followed by dermatitis. The low tube rather than the long exposure must be regarded as the prime factor in this causation.

"This question of the causation of dermatitis has been greatly obscured by the extremely careless way in which cases are reported. Even where details are given as to strength of current, time, distance of tube, etc., how very seldom is any description at all given of the tube itself. This, then, is my first point: that dermatitis is due to a condition of the tube. I think that dermatologists are agreed that X-ray dermatitis is the same as that produced by the violet rays of sunlight and of electric-light, which is still richer in violet rays than sunlight. Then comes the question: Is the dermatitis a *necessary* accompaniment of the X-ray treatment—to be used, but regulated? On this point I adhere to my opinion of 1899. It is, as it were, a by-product. *It is not only no help, it is a hindrance.*

"I do not say that dermatitis will not cure certain skin diseases. It is well known that chronic inflammations can sometimes be cured by acute ones, but what I do say is, that it is not the *X-ray* cure. Moreover, I believe that the two effects are produced by two totally different agencies; not even by different degrees of the same agent. It may be, and probably is, the case, that dermatitis is produced by violet light rays, but the X-ray cure proper is probably not due to any kind of a light-ray, but to *electric current.* This I know is a flat contradiction of a statement I made in 1899. At that time many scientists, both at home and abroad, suggested that the therapeutic effect of X-ray tubes was due to electric discharges, which suggestion I treated with scorn, because I had been working with powerful electric discharges for years, and had never seen any effect produced on the skin, either for good or ill. *I know now how I was misled,* and it confirms me in my present view. Even at that time my attention had been drawn to some similarities of effect of an electrical discharge and an X-ray tube. They both will affect a sensitized plate; they will both provoke fluorescence; they will penetrate the skin and act on the blood-vessels and sweat-glands. Electrical discharges will pass through white glass, but not red, and they have been in use for three or four years in France in the treatment of skin diseases. They both have very marked analgesic properties. All these things have been theoretically known to me for a long time, and it annoyed me not a little that, possessing as I do an electro-static machine giving a brush discharge two or three inches long, I yet could not get the skin effects reported by the professors at Lille.

"The mystery was cleared up in a rather roundabout way. I was endeavoring a short time back to get some information on the phenomenon of fluorescence, and I came upon an article in which it was ascribed to the action of oscillating high-frequency currents. Now, I was very much interested in oscillating currents at the time, as the French journals were full of accounts of their action on *lupus* and other skin diseases; so I set to work to study the fluorescing action of electric discharges, working with my Static machine. I found that the most brilliant effects could be produced on the fluorescing screen, but only when it was held close to the point giving off the discharge. Now, if the special skin action is due to the same property of the current that produces the fluorescence it is probably inactive at a distance beyond which fluorescence can be produced; hence, the fact that patients ordinarily treated with brush discharges are not subjected to dermatitis. I experimented on a patient who had a patch of lupus on her arm, and the result was excellent. High-frequency currents also produce fluorescence at close quarters. Here, then, we have the same phenomena produced in three different ways, by an X-ray tube, by high-frequency currents, and by static-brush discharges. *All three possess similar therapeutic powers*, and it seems to be highly probable that *the same agent* is at work in all of them.

" For the last two months I have been using the tube and the high-frequency currents on the same patients to test the similarity of action, and I will give you the result of my observations. But I must ask you to bear in mind that my H. F. currents are not produced in the orthodox d'Arsonval, but after a fashion of my own. I had an Oudin resonator made according to directions given by the professor in one of his published papers, and I attached it to my *Static machine*.* It works very well. I had at that time a patient who had three patches of lupus—one on her nose, one on her arm, and one on her leg. The nose had been under treatment twice before, and both times the treatment had been given up before obtaining a satisfactory result. The patches on her leg and arm were quite fresh, of much the same age, and covered up with piled-up rupoid scabs that made me think there was probably a congenital specific taint complicating the lupus. After the scabs had come off, I treated the leg with the X-ray tube, the arm with the brush discharge, at first direct from the Static machine, and afterward from the high-frequency attachment. The two patches behaved in exactly the same way and kept pace with one another; perhaps the leg got on a little faster. The treatment with the X-ray tube was kept up for ten minutes each day; with the electrical discharge, for only from three to five minutes, yet the results were equal.

" But a still better case turned up shortly afterward. This was a woman with an exuberant growth on the end of her nose, making it about the size of a billiard-ball. The whole of the end of the nose was concealed in the mass, with the exception of the left ala, which

* The high-frequency attachment for Static machines is now regularly made in this country and its uses will be taught in a later section of this course.

had only one or two isolated tubercles on it. The mass rose abruptly from the skin, the surface was roughly granular, intensely red, bleeding easily, and exuding a sanious fœtid discharge. It was not, and never had been, ulcerated, and there were no scabs. It was said to be about two and one-half years old. It had been diagnosed by an eminent London specialist as tuberculosis, and he had treated it for three months with an ointment containing pyrogallic and salicylic acid with no result. The right half of the upper lip was covered with a thick hard patch, which had been there seven or eight years and had been scraped. The patient suffered no pain whatever and her general health seemed good; but she said pathetically that she was very tired of her nose. And no wonder! I contemplated it with some dismay. It was not a nice thing to meddle with, and only the reflection that no nose at all was better than such a nose emboldened me to undertake the treatment.

"I treated the *left* and least involved side *with the high-frequency current*, actually sparking it for from three to five minutes. The tumor itself was very insensitive. The *right* side I treated with the X-ray *tube* for ten minutes at a time, always with the tube at *the highest possible degree of X-radiancy.* The effect was immediately apparent. The surface of the tumor became drier, smoother, and paler, and the next day there were small scabs scattered over it. *Exactly the same effect was produced by each method of treatment.* The redness and swelling which had extended up the nose nearly to the bridge also gradually diminished. She has now been two months under treatment. The same process repeats itself again and again; the scabs form, come off, leaving a raw, granular surface, more scabs form, and the tumor steadily diminishes. The fetor entirely disappeared the first week of treatment. In one particular the high-frequency current seems to work better than the tube, and that is when long-standing disease has left great thickening. I found that was the case also with another patient who had suffered for thirteen years, and with whom the disease had been quiescent for eight years, so that now I am treating the woman's upper lip with a high-frequency current, although it is properly the tube side of her face. There has been no sign of dermatitis.

"This case has strengthened my belief that the same *therapeutic* agent must be at work in both methods of treatment, and that it is not the same agent that produces the dermatitis. Certain phenomena that I had noticed in the early days of my work with X-ray tubes then came back to me. At one time I was treating a very bad case of psoriasis, where there were large patches of abnormal skin which changed very rapidly under X-ray treatment, sometimes even after one sitting. I soon began to notice that there was a very well-defined area of activity of the tube. I could easily distinguish a round patch of healthier looking skin in the midst of the diseased-looking area; but when this patient became a victim to the soft tube already mentioned the inflammation extended far beyond this healing tract. I have often noticed, too, how the dermatitis has a trick of appearing when you don't expect it. I then examined the tube with the fluorescent screen for the area that would correspond to the healing area on the skin, and I found it represented by a fairly definite area, giving a more intense fluorescent effect and coming always from a part of the tube opposite the edge of the anode—that part of the tube that would be affected by brush discharges from the edge of the platinum plate.

"I have said that this area on the screen is one of more intense fluorescent effect, but I am not sure that this is correct. I have thought that fluorescence proper only shows itself in that area, and that the transparency of the rest of the screen is simply illumination. Illuminating rays act on all parts of the tube in front of the anode, which is the source of the X-ray light. If you send a current into a tube that has lost its vacuum, you will see the discharges flying off the edges of the electrodes to the glass of the tube, and wherever they touch the glass wall you will get fluorescence, though there is no light in the tube and no X-rays. And here again you will only get the fluorescence at close quarters. Then the question naturally suggests itself: If the fluorescing agent from the tube is an electric discharge, like other fluorescing discharges, how is it that it will act at so much greater distance? The reason may be that the currents use the X-light-rays as conductors. All *ionized gases are conductors of electric currents.* The practical outcome of it is this: The therapeutically active area of a tube is that represented by this intensely bright spot; that this spot comes from the part of the glass-wall of the tube that would be most powerfully affected by brush discharges from the anode; that the brighter the spot the more marked is the therapeutic effect, as I have found by experience; and, finally, that the agent in the formation of this bright spot is an electrical discharge.

"One more remark I want to make on the comparative effects of X-ray tubes and electric currents, and that is, in *the removal of hairs.* There are, I know, skilled operators who are content to perform that operation without avoiding the dermatitis which they think is a necessary part of the process. I still maintain, as I did in 1899, that they are wrong, and I am glad to see that Schiff also still clings to his first method, *and avoids the dermatitis as being unnecessary.* The only case of dermatitis that I had in a case for the removal of hairs *was the only case in which the hairs did not come out.* In all my other cases the hairs came out with nothing more than a slight soreness of the skin, and *they have not returned.* One of my cases has now been two years under observation, and another for three years, without a new growth of the hair.

"And this effect, what is it physiologically? As regards the hairs, I think that it is plainly enough a prolonged constriction of the vessels, ending in starvation of the papillæ and hair-roots. A hair that is extracted after long tube-treatment has no root; it ends in a point, with no structure at all to speak of, and no medulla. Probably there has been electrolytic action as well. The action on new growth is, I think, explainable on the same theory. The superficial layers of epithelium undergo starvation, necrosis, and shed themselves in scabs. New growths of epithelial tissue are easily starved. The cells are not in very intimate connection with their blood-supply. The action only affects the superficial layer, and a process of gradual destruction goes on which would not be sufficiently powerful to injure more highly vitalized tissue. Having destroyed the growth, the next thing required is to restore the normal tissue from which the disease has sprung until it has attained strength to fight its own battle and no longer offers a suitable field for the growth of germs, and electric currents certainly do this. The treatment of rodent ulcer ought to show this process well. Two cases that were treated in the Finsen Institute last year seem to have behaved much as the nose that I have spoken about.

"There is an erythema which is produced by electric discharges, which I have also seen after prolonged use of the tube, and which has, I believe, in many cases *been mistaken for X-ray dermatitis.* I have seen it mentioned in reports of cases where very brilliant tubes have been used, but the reports have not distinguished it from X-ray dermatitis, though it is very transitory, while we all know that the other is not. It always appears after severe applications of high-frequency currents, is slightly sore to the touch, and lasts two or three hours. It is much more pronounced in hairy tissues, where it generally produces slight swelling, the soreness is more pronounced, and the condition remains for two or three days.* I have often seen it induced by the careless adjustment of the tin-foil masks. It is easily distinguishable from X-ray dermatitis by its beginning superficially. If it has been at all severe the skin peels after it.

"It is now the generally accepted belief that hard tubes *never cause dermatitis.* I never use screens except for the face, and then only to protect eyelashes and eyebrows, and I make them of an ordinary toy mask, which I cover with tin-foil on the outside next the tube, and I take care that the edge of the tin-foil does not touch the skin. I never use any screen with the high-frequency current, nor do I cover any part of the tube. With the theory that not washing the skin will insure you against dermatitis I entirely disagree, and I never tell my patients not to wash their faces when I am treating them for superfluous hair. On the contrary, when hairs have become deteriorated in the course of treatment, *a good rub removes them.* The way to avoid dermatitis is *never to use a soft tube*, and if we give up the theory that the therapeutic effect is due to X-rays there is no object in using a soft tube, while, on the other hand, if we consider this effect to be due to electrical discharges it does not matter how hard a tube is. Many operators, beside myself, have commented on *the difficulty of producing a dermatitis to order.* Many of us have tried and failed."

* Sedation with a negative Static breeze by the author's method relieves this condition in five minutes usually. (S. H. M.)

CHAPTER XXXIX

THE X-RAY TREATMENT OF LUPUS

TECHNICS AND RESULTS. DIRECTIONS FOR APPROVED METHOD.

LUPUS has been the great battle-ground on which X-ray therapy has won its chief recognition, but the world-wide interest in its action in this disease springs in part from the hope of finding in some feasible form a remedy against tuberculosis and cancer. We shall presently take up these diseases in connection with the X-ray, but first invite the careful study of readers to what many now consider "the positive cure of lupus." Deriving the most instruction from comparing the views, methods, and results of different workers, we shall cover in this chapter the best that is known on the subject.

Holland's first cases were presented with the following paper on December 10, 1898:

"Since June 1, 1896, to the present date, I have taken 725 radiographs, the plates of which I have kept. In addition have made a number of unsuccessful exposures, and done a very large amount of fluoroscopic work. Further, I have superintended the X-ray work of a friend for more than a year, his apparatus being in daily use. The coils have been three-inch, six-inch, and ten-inch, and the exposures have varied from a few seconds up to an hour. Several abdominal and hip cases (all long exposures) were within a short space of time exposed two or three times. The tubes have been placed at distances varying from four to fourteen inches from the skin. The apparatus used has been the simplest—an accumulator, a coil, and a tube. No attempt in any case at any protection. With this somewhat extensive experience *I had never seen the slightest damage of any kind*, not even the removal of a single hair nor the appearance of the slightest redness of the skin. In April of this year, 1898, hearing that lupus had been successfully treated by X-rays I borrowed two cases to see what could be done.

"Case 1.—A girl. The photograph taken, 1898, presenting a chronic irregular punched out, tubercular ulceration in the foot which lasted for eleven years. It was at that time very painful, discharging freely, and almost incapacitated the girl from walking. Varieties of treatment had been unsuccessfully tried. All treatment except the use of boracic ointment was stopped, and, between April 18 and June 14, 1898, the foot was exposed to X-rays nineteen times. The glass wall of the tube was placed four or five inches from the skin, and the anode was kept red hot during the time of each exposure.

"A ten-inch coil was used each time except once, when a six-inch was used. On May 24th the ulcer was much better. On May 31st there was no discharge. On June 14th, when X-ray treatment was stopped, all pain had ceased, there was practically no discharge, the nails of the toes were all loose, and a slight erythematous blush extended over the dorsum of the foot and a little up the leg. The girl could wear a boot and walk with comfort. No further treatment was given until November 15th, when the second photograph was taken. We have only to compare these two photographs to see the great change in the appearance. Am now commencing to give the foot a few more exposures.

"Case 2.—A boy of sixteen with a large ulcerating lupus attacking the left face and left ear with discharge from the ear. It was of five years' duration and had been constantly scraped and caustics applied with but very temporary benefit, and the lupoid patch was slowly extending in area. On April 18th all treatments were stopped except boracic ointment.

"*Between April 18th and June 14th he was exposed seventeen times, for fifteen minutes at a sitting. The ten-inch coil with a tube, the anode of which was kept red hot, was used on all occasions except one. The glass wall of the tube was four or five inches from the skin.* After eleven exposures some hair on the side of the head next to the tube began to come out, and was so rapidly shed that in a few days he had an absolutely bald patch extending in a semicircle from behind the ear upward to the forehead. The line was a most perfect regular curve. It seemed to me to more or less accurately correspond to the margin of the screen of X-rays. At this time the lupus was drying up so that he was able to leave off the ointment and wear no dressing at all. On June 14th, the date of the final exposure, it was practically healed. Seen again on August 11th it was entirely healed. There was no sign of recurrence, and the hair was growing well again. The beginning of October I showed the boy at the Liverpool Medical Institution, and the dermatologists there, four in number, agreed that the case was cured and that there was no evidence of lupus at all. In this case no other effect occurred beyond the loss of the hair, and this rapidly renewed itself. There was no dermatitis set up either in or around the lupus, and no attempt at protection of the surrounding parts was made. Photograph No. 4 shows the present condition of affairs taken in November. The scar is white, soft, and healthy looking, and presents no suspicion of any lupoid disease. (See Plates No. 169 and 170.)

"In another case of lupus I have tried this treatment—a boy of eighteen with a patch similar to the last, except that there was no involvement of the ear and it was on the opposite side of the face. It was of eleven years' duration, but it was of the dry-scale variety without any tendency to ulcerate. This case was steadily getting worse and extending, notwithstanding scraping it at different times. Between June 27th and July 16th he had eighteen applications under similar conditions to the last case, except that the face and head around the lupus was protected with a piece of lead. At the end of the treatment the patch ulcerated all over, but rapidly healed with boracic ointment. I saw the boy quite recently and he certainly showed a change for the better, but the case was very far from being cured. He is now undergoing further X-ray treatment. One other case, not my own, I have seen—a young woman with a most malignant type of lupus, affecting the nose, lips, the mucous membranes of the nose, lips, and both cheeks. This case had been repeatedly scraped under chloroform, had had pure carbolic acid rubbed in, and so on. Only temporary benefit followed each operation and rapid relapse took place. Exposure to X-rays without curing has vastly improved this lupus, and she had a fairly long period of considerable relief and benefit following each course of treatment.

"Analyzing these cases: in that of the foot there was loss of nails and slight erythema. The nails soon grew again and their loss caused no inconvenience. In the two cases of lupus of the face: in one, the dry non-ulcerated form, the whole lupoid surface broke down into an ulcer; and the other, the ulcerating case, there was steady healing almost from the very first few applications, and, although some of the hair on the scalp was lost, there was never any sign of any inflammatory change of the skin around the lupus, not even the slightest redness. One point was of special interest in this case, and that was the sharp line of demarcation where the hair came out, a curve which might have been drawn with a pair of compasses, and, as I said before, it appeared to correspond very accurately with the margin of the X-ray screen, pointing to the probability that it was caused either by the X-rays themselves, or by some other rays coming off with the X-rays. The hair grew again very rapidly, and, if anything, more luxuriantly than before.

In a second publication, dated May, 1901, Holland continues: "In December, 1898, I described a case of lupus of the face treated and cured by X-rays. Until May, 1900, the case remained entirely well—a period of nearly two years. Then there was distinct evidence of recurrence of the disease at the lobe of the ear and at the lower extremity of the scar close to the chin. These two parts became slightly scabby and inclined to ulcerate, the central scar area remaining quite healthy. Between May 9th and 21st I exposed the area again to the X-rays six times for ten minutes each, using a ten-inch coil with a mercury interrupter and a high-vacuum tube, a primary exciting current of from twelve to thirteen volts and six to six and one-half amperes, with a tube six inches from the skin. On July 24th, the lupus was again healed except for a slightly suspicious patch just at the lobe of the ear, where it is a little scaly. The whole scar is very healthy looking, soft, non-adherent, and non-contractile. The lupus remained well until early in 1901, when the disease again returned not only at the lobe of the ear, but in scattered nodules, here and there, over the scar area. At this date, March, 1901, the case is having further X-ray treatment.

"On February 5, 1900, there came to me a girl eight years old with a lupoid patch on the left side of the face three-quarters of an inch below the eye, almost circular, and slightly larger than a half-penny. It was ulcerating, and scabbed over with a very thick scab, from the edges of which pus oozed out and the ulcerating edge was nodular. There was a family history of phthisis. The lupus began five years previously in a small pimple after an attack of measles and was treated with ointment. At intervals it was scraped under chloroform on three occasions. It never healed after these operations, but looked better for a time. It had no further treatment until August, 1898, since when it has been cauterized four times, the last time being six months ago. It has been gradually extending.

"On February 5, 1900, having stopped all other local treatment, I commenced X-ray treatment. Between February 5th and 17th *it was exposed six times (using a shield of tin-foil) for six minutes, each time working with a ten-inch coil and a mercury interrupter. A high-vacuum tube was used at a distance of four to five inches.* The primary exciting current was twelve volts and five amperes with a spark-gap of from eight to ten inches. On February 17th, a slight red blush was noticed around the scab and treatment was stopped, and on March 15th the scab came off and left a healthy-looking unhealed ulcer. On May 18th this ulcer was almost healed, but two small patches looked a little scabby and suspicious. Between May 18th and 23d she had four more exposures of ten minutes each under the same conditions as previously. On June 21st it appeared to be quite cured, and remains so now in December. On November 9th the second photograph was taken. The lupus is quite cured and its place is occupied by a soft, healthy scar, non-adherent and non-contractile. The latter point is well brought out by the fact that there is no pulling down or erosion of the lower eyelid. The scar is almost white, and at a few paces distant can scarcely be seen. In considering the treatment and its results, with the above cases before us, there are several points worth dwelling upon.

"1. *It is not necessary to set up any primary effects such as dermatitis, etc.* In the first case, no protection was used for the healthy skin and parts surrounding the lupus, and half way through the treatment a large patch of hair on the side of the head nearest the X-ray tube fell out. The hair grew again very rapidly. In the second case, layers of tin-foil were used to cover and protect all the parts around the lupus. A red blush appeared in the healthy skin just around the patch after six exposures, when treatment was immediately stopped for a time. And it is certainly sound advice to give, that *on the first appearance of any inflammatory mischief, no more exposures should be made until it has entirely disappeared.*

"2. In both these cases a *very high-vacuum tube* was used at a distance of from four to five inches from the diseased area. The ten-inch coil was worked from a six-cell storage battery, giving an E. M. F. of from twelve to thirteen volts and six amperes, the actual spark being from eight to ten inches in length. This differs from the plan adopted by some workers, who have used a current of much smaller amperage, with low-vacuum and smaller spark-gap. *There does not seem to me to be any danger in using these stronger currents,* and this leads me to my third point:

"3. The *very few exposures needed* to cure these two cases. The first case had only seventeen primary exposures of fifteen minutes each, and, two years afterward, six exposures of ten minutes each sufficed for the slight recurrence. The second case had altogether ten exposures of ten minutes each. Perhaps the two cases were very suitable for this method of treatment, but the number of exposures are very few compared with other published records of the X-ray treatment of lupus.

"4. The fourth point is the gain to the patient. With this method there is no anæsthetic, no operation, no pain; and all these are most important from the patient's point of view. *The resulting scars are far superior to anything of the kind I have ever seen from any other method.* Both are very soft, almost white, entirely non-adherent, with no tendency to contract—and when situated on the face these points are of the utmost importance. In the second case, situated so close to the lower eyelid, by almost any other means we must have had some draggings in the eyelid which would have necessitated an operation for its cure.

"It seems to me that in future, in all cases of lupus, the X-ray treatment ought to be given a trial before any other methods are adopted. *It ought to be the first thing recommended* not only in the bad cases which have been going on for years, but also in the early stages of the disease, when certainly it would have a much better chance of not only arresting, but curing the disease. I do not think that in proper hands there is any risk at all to the patient from the so-called X-ray burns, while the gain to the patient in avoiding pain and disfiguring operations is very great." (Holland, May, 1901.)

Schonberg reported nine cases of success in 1898 as follows:

"The applications lasted about a half hour each day, with interruptions of different periods in the different cases. In all cases the effects produced follow more or less the same course. The skin first shows a slight yellow tint, which is soon followed by general redness of the affected part. This redness deepens in colors, and with some patients slight itching and pricking sensations are felt, together with a feeling of warmth. A sensation of a tightness of the skin also follows in some cases, with slight œdema. Excoriation is generally produced, the appearance resembling that of a burn and extends up to the edges of the area protected by the mask. The skin generally heals from the edges toward the centre. As soon as the redness begins to show itself the sitting should be discontinued, and it is important to keep a close watch on the effects produced during the first applications *to avoid a general dermatitis which hinders the cure.* To protect the parts not under treatment a mask of cardboard is used covered with tin-foil, which is more convenient than a lead protection, especially when dealing with the face. The following is a brief summary of the cases described:

"1. Miss M., aged fifty-three, lupus of left cheek, under medical treatment twenty-eight years. Applications of X-rays with intervals for six months.

"2. Mr. R., aged twenty, nose and upper lip. Medical treatment for three years. One hundred and fifty-one X-ray treatments during eight months.

"3. Mrs. R., aged forty-eight, nose and right cheek. Hospital treatment for two years. Applications of rays spread over six months.

"4. A. K., aged thirteen. Nose and upper lip affected for four years. Twenty-eight applications during three months.

"5. Miss B., aged thirty-seven. Suffered from lupus of nose since twelve years of age; forty-six applications during three months.

"6. Miss W., aged twenty-seven. Small spots on both cheeks and forehead. Under treatment for four years previously. Eleven X-ray applications during one month.

"7. Miss M., aged eighteen. Lupus of the face. No previous treatment. During two months gave fifteen X-ray treatments to left side and ten treatments to right side.

"8. Miss K., aged forty-six. Upper lip, nose, and both cheeks affected; under other treatment for twenty-three years. Treated left cheek with X-rays. Sixteen applications, spread over two months.

"9. Miss K., aged thirty-six. Both cheeks and nose affected. Medical treatment for eleven years. Sixty-eight applications of X-rays."

The first cases of lupus and tuberculosis of the skin treated with X-rays by Jones were exposed as follows:

"The face, which was involved from the hair-line to below the lower margin of the jaw, including the entire ear, was protected by a heavy lead plate perforated with a hole to correspond with the area involved. *Exposures at four inches distance were then made with a low-vacuum tube three times a week, séances lasting from two to eight minutes.* The length of the exposure and the frequency of treatment was decided largely by the effect on the skin. When it was too reddened sittings were made shorter and less frequent. A slight dermatitis developed just below the eye and a slight conjunctivitis was also produced, but these troubles shortly passed, and, indeed, were but trifling in the first instance. The maximum intensity of the rays was directed toward the lower portion of the area involved, and this portion improved more rapidly than the ear and upper portion. The same plan was adapted to the situation of the lesion in the second case."

Varney discussed the treatment of lupus by the X-ray in February, 1901, and compared the stimulating influence on the tissues with the similar action and results of Finsen's photo-therapy. He stated, "The results are about the same except that the X-ray is somewhat more rapid in its action, with shorter exposures, and larger areas may be treated at a sitting. *The treatment of lupus by the X-ray is painless, its exposures are of short duration, and the area treated may be of any size or location. There is no scar from the treatment if the exposure is properly conducted.* The time of exposure is regulated by the intensity of the rays, and the results are evident, with much less scarred tissue."

In February, 1900, Hall-Edwards reported the case of a boy fourteen years old, with lupus of the face, lasting eleven years under constant treatment. The disease covered nearly the entire face, and had destroyed a great part of the nose. There was also a patch on the instep of the left foot, and this was treated by exposure to X-rays, with the tube but one inch from the part. Four exposures were made, varying from ten to twenty minutes each. The diseased patch then broke down, leaving an ulcerated surface which healed under careful treatment, and has remained well twelve months. In a second case, a girl had lupus covering the entire face, with the exception of the chin, and also a patch about two inches in diameter on the right arm. The patch on the arm was successfully treated by use of the X-rays. In a third case, a girl who had lupus of the face and right thigh was treated with a successful result.

Geyser* reported four cases of lupus as follows:

"Case 1.—In a sheet of lead a hole was cut to fit the affected area upon the patient's face, which was about the size of a silver half-dollar. The tube was adjusted at two or three inches from the surface, exposures were made every second day from ten to fifteen minutes. Twelve treatments healed the lesion.

"Case 2.—A small lupus patch, diameter about one inch. Treatment same as Case 1. Improvement noted after seventh treatment. Entirely healed in sixteen treatments. While clinically resembling lupus vulgaris these lesions were neither of them considered to be true lupus, as they healed so easily.

* Journal of Electro-Therapeutics.

PLATE 165.—Raying Lupus of the Nose. Photographed especially for this work by Dr. L. E. Kelly, of Oakland, Cal., who writes : "Am treating sixteen cases of lupus, or tuberculosis of different parts. Two very bad cases affecting the rectum ; one with the floor of the pelvis almost gone. Doing exceedingly well." Note the sheet-lead bent round the face with hole cut for affected nose. It is being tied behind with two pieces of tape to hold it in place, and the operator is adjusting the tube to position. When the lower pair of ribbons (seen hanging down) are also tied have the patient drop his hand to his lap, light up the tube and expose as taught.

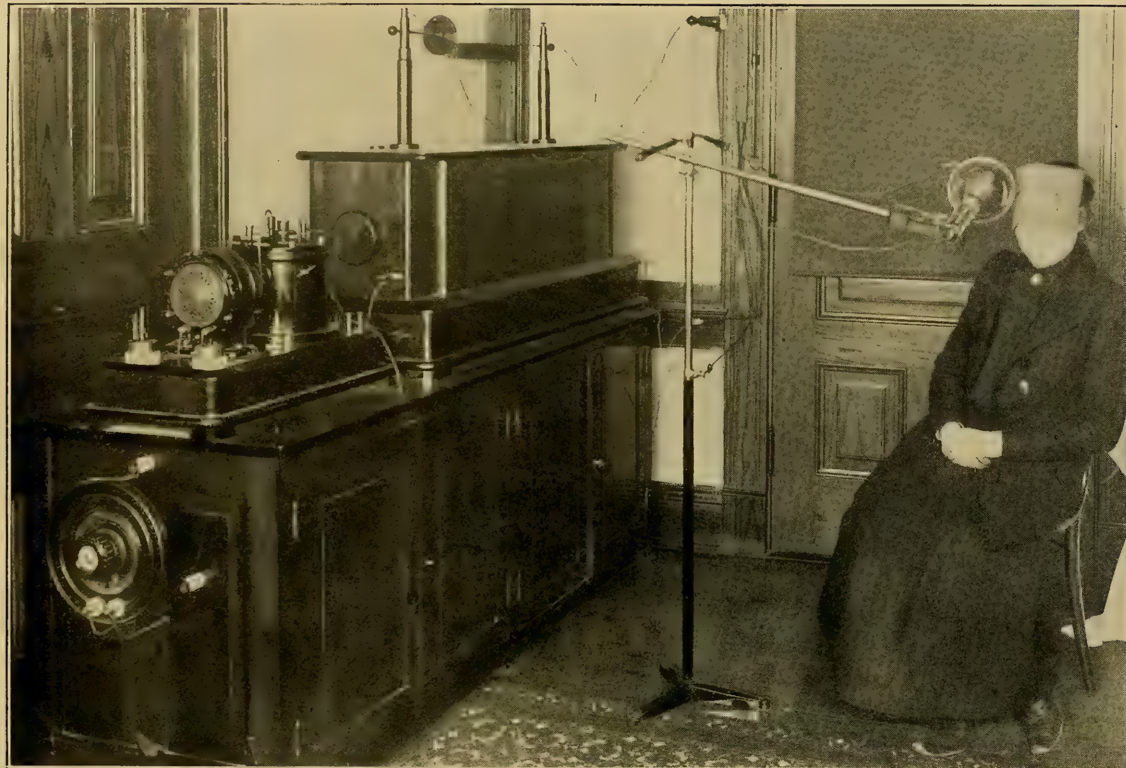


PLATE 166.—"Lupus Vulgaris. One of the worst cases writer has ever seen. The Lupus covered entire face and forehead. The photograph shows method of exposure; lead mask, with opening for forehead, protects hair and eyes. Treatment began May 22; date of last treatment, July 16, 1901. Skin at present time like that of a baby, without a blemish. Tube used, very soft, exposure twenty minutes daily, gradually dropping to three minutes as the 'sunburn' manifested itself." (Blackmarr.)

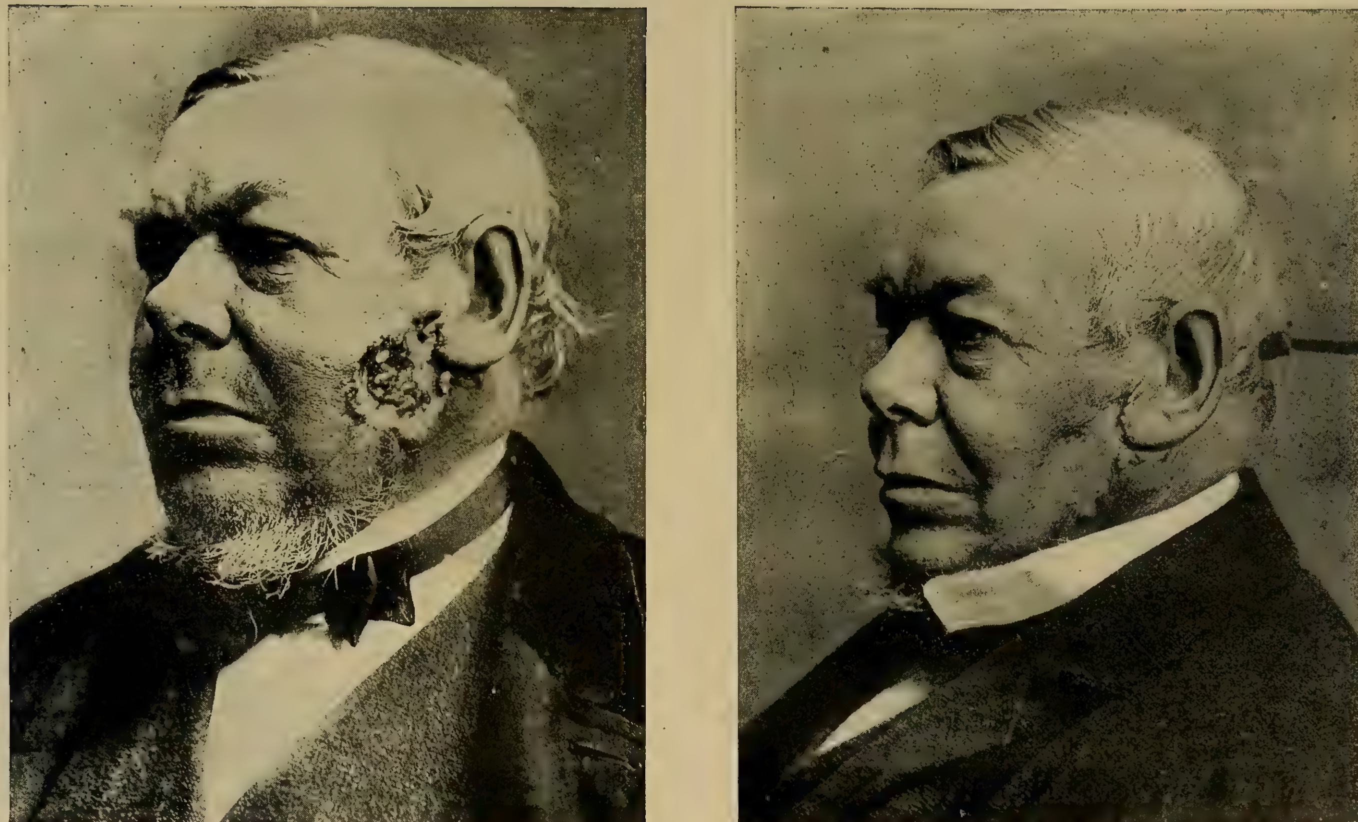


Plate 167.—Before and after X-ray Treatment. (Rebman, Ltd.)

PLATE 168.—Before and after X-ray Treatment. (Rebman, Ltd.).

"3.—Lupus of eight years' standing, which had resisted various treatments. Diagnosis of lupus vulgaris was substantiated by pathological examination of a specimen taken from the left cheek. Treatment same as before up to tenth séance. A severe dermatitis then developed on the back of the patient's right hand, which he had been in the habit of resting upon the table directly under the tube. The dorsum of the hand was swollen and intensely red, with severe burning pain. In a few days blebs formed very much after the manner of an ordinary burn. The hand was dressed with zinc stearate dry, and kept so with ordinary bandages. Immediate improvement resulted. The pain lessened, swelling disappeared, the skin peeled in large patches, and was at once replaced with sound skin. Four weeks later ridges appeared across all the nails of the affected hand, showing the effect of the trophic disturbance at the matrix. The index finger on the affected hand had previously been swollen, stiff, and more or less sensitive on manipulation, and appeared like a tuberculous joint. This pain and stiffness somewhat disappeared, and even the contour changed. At the tenth treatment little if any improvement could be observed in the condition of the face, but the patient insisted that the *inside* of the mouth and the nose were improving. The patient stated that an obstruction in the nasal passage interfering much with breathing was freed; that the swelling, tubercles, and hard nodules on the inside of her cheeks and lips were disappearing; that she felt as though she had more room in which to move her tongue; and that she could pass her tongue between her teeth and lips, something which for years she had been unable to do.

"At the eleventh séance and thereafter, treatment was changed to the static spray." [For full directions see author's works on "Static Electricity."] "Much improvement ensued even from the first spray treatment. This was continued for six treatments, when a pause of two weeks was made to see if the improvement would continue or lapse. During the first week no change was manifest. About the tenth day the affected area appeared to grow worse, and the patient suffered excruciating pain all over the face, especially in the upper and lower lips. For three days and nights the patient was unable to eat and sleep; the pain became unbearable, and she begged that treatment be resumed. Upon commencing treatment all pain immediately vanished. The patient was able to sleep after the first application of the spray. The spray treatment has been continued twice a week, or less, and at the time of this report was not completed.

"Case 4 was a mild one. The patient objected to miscroscopic examination. Rapid improvement was made under the static spray, and after the sixth treatment the patient left for the country."

"In a discussion of these cases a physician present related that he had recently a case of lupus, a chronic case, which had been treated by a number of physicians, but as the patient lived out of the city he could not attend for X-ray or electrical treatment. From its history and symptoms a diagnosis of lupus was made. 'Three weeks ago I suggested to the man that he take a simple magnifying-glass and concentrate the sun's rays upon it three or four times a week, continuing the treatment for four or five months. When I last saw the case the growth had apparently ceased, and there was no further invasion of the tissue. I have just received a letter, saying that the growth had practically healed, had dried up, and that the patient felt he was well, but would continue the treatment another month to make sure.' "

A case of lupus of the face uncured and under further treatment by the X-rays was reported by Dr. Hills Cole.

"My patient had been in the habit of steadying the lead-plate protector with his hand during the treatment. Some time ago he noticed a roughness of the finger-nails of the hand that touched the plate. The distal phalanges of the fingers came above the plate. Marked rugæ appeared in the nails, and subsequently the old ones fell off and were replaced by a new growth." (Avoid this.)

Pusey contributed the following to the study of lupus:

"The patient, a married woman aged thirty-eight, was referred to me May 8, 1900, with a diagnosis of lupus and for treatment with X-rays. The condition at that time is shown in the accompanying photograph, Fig. 1, which I took when I first saw her. The extent of the disease on the left side of the face and the neck is indicated in the photograph. It also extended over on the right side of the chin and up on the right cheek beyond the angle of the mouth. This entire area was covered with lupus ulcers and unhealthy scars. The ulcers were the typical flabby, soft, indolent ulcers of lupus covered with reddish-brown crusts. The scars were thick, red, bandlike, and very disfiguring. The scars were most marked under the chin, and they were sufficiently rigid to materially interfere with motion. At many points in the scars there were recurrent ulcers. Typical 'apple-jelly' tubercles of lupus were easily demonstrable in any part of the diseased area. The point of greatest activity of the lupus was an area with a diameter of perhaps two inches around the left angle of the mouth. The ulcers involved the mucous membrane of the lips at this point, but no lesions were found within the buccal cavity. There was no evidence of tubercular involvement of the deeper structures. There were no deep sinuses and no tubercular glands. The case was, in short, a lupus and not a scrofuloderma.

"I have sections made from a piece of tissue taken from the border of an active ulcer. These sections show the structure of tuberculous tissue. Tubercle bacilli were found in this tissue by me, and independently in other sections by Dr. Roehr, of the Columbus Laboratory. I was fortunate in having the case seen by Dr. H. G. Anthony, professor of dermatology in the Chicago Policlinic, when it first came to me; he agreed in the diagnosis of lupus.

"While the lesions were freely ulcerating, the surface was covered with boric-acid vaselin, and in the morning before the treatment by X-rays the ulcers were lightly cleaned with cotton-sponges wrung out of a weak bichlorid solution. The ulcers, however, were never washed with bichlorid solution, and the case has had no other local treatment. The patient has had no internal treatment of any kind until within the last month, and then only a pill of reduced iron, arsenious acid and strychnin, t. i. d.

"Treatment was begun by exposure to X-rays on May 8th, and was continued daily, except Sundays, until May 26th. By May 24th many of the lesions were clearing up and beginning to heal. May 26th the exposed surfaces showed some reaction from the effects of the rays; the lupus tubercles were brighter in appearance and the borders of the ulcers redder. Treatment was discontinued until June 4th, by which time the reaction had almost disappeared. The treatment was continued from June 4th until June 21st, daily, as before, when considerable dermatitis developed. This dermatitis was confined to the diseased tissue and did not involve the surrounding healthy skin which had been exposed to the rays. At this time the ulcers were healing rapidly. The treatment was discontinued until July 2d, when reaction had entirely disappeared and almost all of the ulcers were healed. From July 2d till August 10th the treatment was continued, not daily, but with a few intermissions of three or four days as the condition of the face indicated. During this time there was gradual improvement in the condition, the remaining ulcers healing, tubercles being absorbed, and the entire surface becoming covered with healthy scars.

"By the latter part of July the left side of the face showed few traces of the disease. The diseased area on the right side, however, which from the manner of making the exposures had received less of the effects of the rays than the left, still showed lupus nodules and open ulcers. Accordingly, additional exposures were begun directly over this area on July 30th and continued daily in a maximum amount until August 10th. Under these extra exposures the lesions immediately began to improve and by August 10th had entirely healed.

"On August 10th treatment was discontinued, because of my going away. At that time the only evidence of lupus that I could find was at the angle of the mouth, where there was still a focus of disease. On September 13th the patient returned; there was then no evidence of disease at any point except at the angle of the mouth, where the tubercles persisted. Treatment was resumed with exposures over the left angle of the mouth. September 20th the tubercles on the upper lip were breaking down and an elliptical ulcer the size of a little-finger nail had developed, which within the next few days began to heal. On October 2d some erythema over the exposed area had developed and treatment was given up until October 8th. By October 8th the last lesion had disappeared. From October 8th to date the patient has had daily exposures on the left side of the chin and on the neck under the chin.

"These exposures have been continued for two reasons: 1, *the old keloid-like scars had shown under the exposures great improvement in flexibility, softness, and color*, and it was desired to carry this effect as far as possible; 2, to destroy any concealed lesions still present. Since October 8th I have not been able to find any evidence of disease.

"The results of the treatment are indicated in photograph, Fig. 2, taken November 10th. There remain now, excepting the scars, no evidences of the disease; and even should more or less recurrence of the lupus take place, I believe the results may still be called *extraordinary*. Attention is called to the character of the scars. The only thick ones left are those which were in existence before the treatment began, and they have become less prominent, much softer and more pliable. The scars which have taken the place of the ulcers present when treatment began are soft, thin, flexible, and white, and are as healthy looking as they could possibly be. At the beginning the scars on the neck interfered very considerably with motion; now they interfere scarcely at all.

"*Certainly none of the usual methods of treatment by surgical means could produce such a result.*"

A case of lupus of fifteen years' duration was reported by Smith.

"Frank Nichols, aged about eighty, consulted me for an ulceration of nose and face which was involving his right eye. I found he had a lupus patch which extended from the left side of nose, going over the bridge and involving the right side of nose and inner canthus of right eye and the inner thirds of the lids, together with the bulbar conjunctiva. About fifteen years ago he was slightly injured by a chip striking him on the nose, breaking the skin. It never healed over, but slowly increased in size, notwithstanding he had been treated by a score of physicians, a few skin-specialists, and numerous quacks. About a year ago it invaded the eye, since which time it had progressed more rapidly in the mucous surface. There never was much pain; it bled occasionally and disfigured him much. His general health and family history were good. No specific taint was elicited. I made a mask for the face of sheet lead, cutting a hole for the nose and diseased part of right eye, and with this on, exposed him about every fifth day for twenty minutes at a time, the diseased surface being placed about two inches from the light. He received in all twelve treatments. No medicine whatsoever was allowed. He was using applications of vaseline at first, but that was denied him. Marked improvement commenced after the second treatment, and was not interrupted until the sore was completely and entirely healed. After the second treatment healthy granulations appeared and healing was remarkably speedy. There was no burning from the light, or any other unpleasant symptoms complained of,

PLATE 169.—One of Dr. Holland's Lupus cases before treatment. The next plate shows the case after treatment. (Rebman, Ltd.)

Plate 170.—Dr. Holland's case of Lupus after treatment. (Rebman, Ltd.)

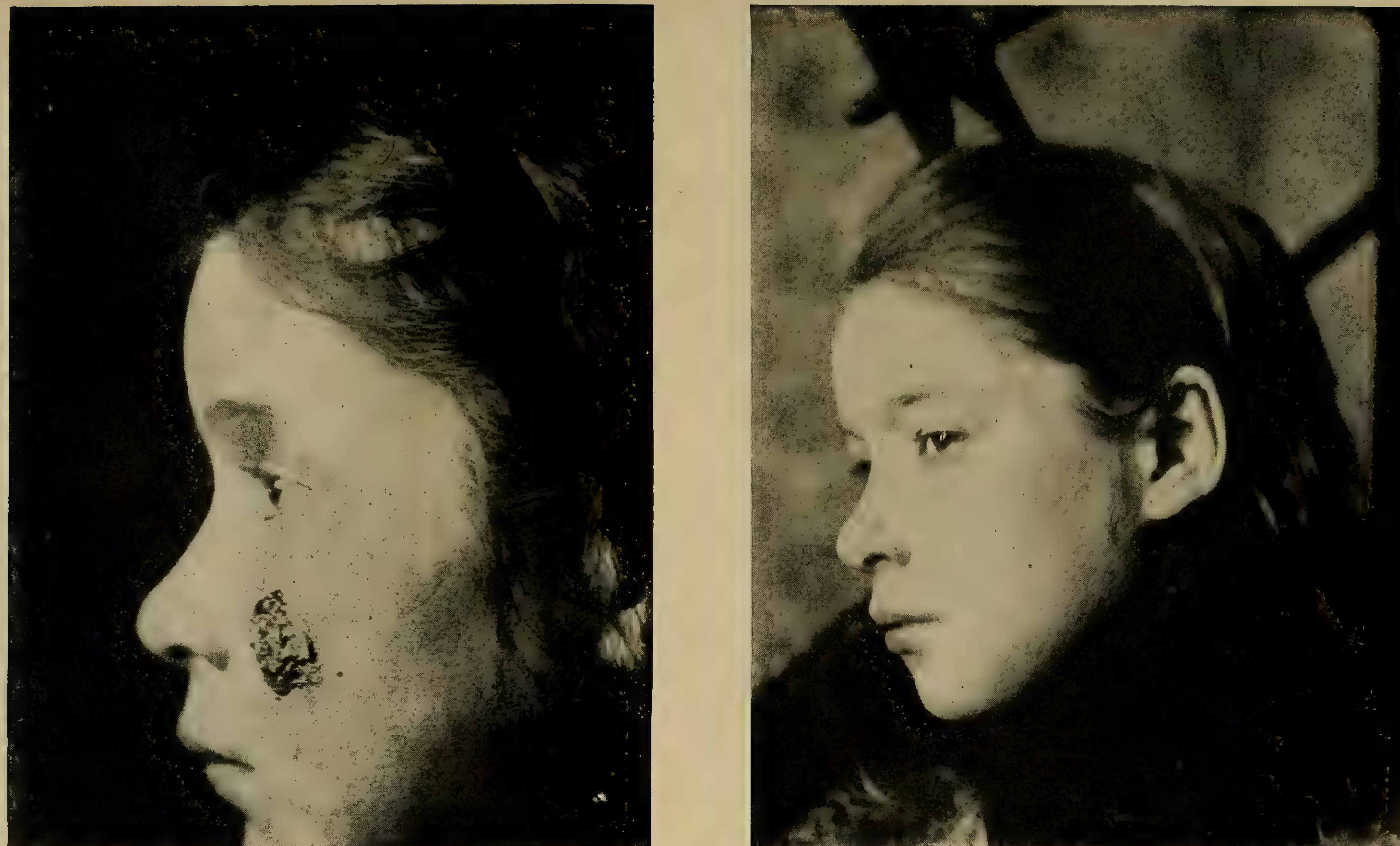


PLATE 171.—Lupus case before and after treatment. (Rebman, Ltd.)

except a slight headache and a decided 'crawling sensation' in the sore after the first two treatments. The cicatrix has produced a slight ectropion by everting the inner end of the lower lid, and has drawn the upper lid down and in, but vision is normal."

Case of Lupus Erythematosus.—"Mrs. G., aged forty-three. Duration of lesion eight years. First X-ray treatment April 1, 1900. Face protected with lead mask with hole cut to fit lesion. Used high-frequency coil and medium-vacuum tube. Exposed for twenty minutes twice daily for three days; then ten minutes twice daily for six days; five minutes daily for three days; then three minutes daily for three days, a total of fifteen days' treatment. She remained for nearly a week after that to enable me to watch the slightly developed dermatitis, which was at no time severe. She returned home with a little color over the lupus area, which was left from the burn, and it was thinner, cleaner, and in better condition than after the first scarification. One week after her return home, word was received that her face had entirely healed—nothing remaining to be seen except a few little scars, probably the result of the scarification. Four months have now intervened, and her letter of July 28th states: 'I was never better, and my face is certainly well.'"

Case of Lupus Vulgaris.—"Mrs. H., aged thirty-eight. Coughs a great deal. Examination of lungs, roughened inspiration over whole area of left lung, few moist râles, sputum not examined. Six years ago was in fair health. Slight hard pin-point elevations appeared upon the middle of left cheek, gradually increasing in size with tendency to aggregate and coalesce. Several ulcers formed in the mass, after a period of a month the whole area enlarging, involving the cheek, soon presented a hideous appearance. The discharge was so vile that the patient was almost driven to suicide. Her mental condition need not be described. This patient began treatment February 5, 1901. The same procedure as with the Lupus Erythematosus case, excepting the use of the low-vacuum tube and prolonging the treatment on the fourth, fifth, and sixth days to thirty minutes twice daily, carrying her to the sunburn point, then dropping the time of treatment to five or three minutes in duration, as I deem wise. In this case I produced a severe burn in the centre of the large ulcer, and two small points near it. These discharged more profusely than ever. One strange feature in connection with this was that after the fourth treatment there was practically no odor.

"After the third week of treatment the large ulcer began to heal, leaving the two small ones discharging. By the middle of the fourth week the two small ones stopped discharging and healing continued rapidly. At this point I gave the patient predigested food and Gude's Pepto Mangan with good results. Five months have gone by without return of the lesion.

"*Ulcer of Leg.*—Male with specific history. Claimed to have recovered from syphilis after three months of medical treatment.

Two years later ulcer appeared on the left leg. No varicose condition present or history of injury.

"Treated ulcer with X-rays for scant two weeks. After the first week the healing process was quite marked. A week after stopping treatment it was almost healed. Five months have elapsed and the patient is well." (BLACKMARR, August, 1901.)

On May 21, 1901, a visiting physician stated to the author that he had himself "cured" three cases of lupus vulgaris with X-rays, and another physician in his city had treated fourteen cases and cured them all. *He regarded X-ray therapy "as a specific for lupus." He also "used it for old ulcers and varicose ulcers with good results; also for epithelioma with fine results."* He puts the tube at first five inches from the part. Exposes five minutes daily at first, and each day gradually puts the tube further and further away till it is ten inches off. He watches carefully for irritation, and if the part whitens or changes he stops treatment for a few days to see what effects appear. If all is well he resumes treatment as before. Usually the hair falls out when the head is thus treated, but it grows in again. He does not know whether the lead protection is needed or not. He "uses it because all do." He carries a wire from a loop in the lead to the ground. Some do not ground the mask. If it is used at all *it should be grounded the same as a Static electrode.*

The following valued communication was written the author by Dr. G. G. Stopford Taylor, of Liverpool, England, to whom fraternal acknowledgment is here made:

"I use masks of lead-foil in which openings are cut a little less in size than the part to be rayed. Unless they are close fitting the rays penetrate beneath the margins of the openings and produce an erythematous zone beyond the area of the disease to be acted on. To obviate this I have found it advantageous in some cases to bind a large piece of raw cotton firmly over the openings, including that portion of the mask surrounding them. The pressure of the raw cotton has also another beneficial effect, as it renders the diseased area more or less anæmic, and this facilitates the penetration of the rays. This so-called X-ray erythema appears unexpectedly and may prove a troublesome complication, for if treatment is not at once suspended it continues to spread and naturally causes much anxiety to the patient and annoyance to the operator. Fortunately, I have never seen it cause more than four or five weeks' delay. The cases in which it is most likely to occur are in very superficial forms of disease, or over bony prominences, or, where there is an absence of fat as in the eyelids. At the commencement of treatment I place the tube a hand-breadth from the disease, and, should no improvement occur after a few exposures, I lessen the distance. I consider the therapeutic effect of the rays as a form of stimulant the like of which we have never seen before; for, while they have the power of producing epithelial growth and the absorption of inflammatory products they also have, if used unskilfully, an escharotic action upon the tissues. Deeply infiltrated cases of lupus, rodent ulcers, and epithelioma, however, have proved remarkably tolerant of the action of the X-rays."

Combined X-Ray and Finsen Methods in Lupus.—A combined method of treatment has been carried out by Morris and Low, especially applicable to difficult cases of lupus of the face and cheek implicating interior tissues. They remark:

"This combined method has been in use at the Finsen Institute, but not systematically. Its rationale is that as the Finsen rays cannot be brought to bear on any other than plane surfaces, the X-rays, by virtue of their power of penetrating soft tissues, may be used to act on the mucous membranes, however complicated their arrangement and situation. A good instance was a case implicating the interior of the nose. A mask was made of card-board and lead-foil, and applied to the face, with a hole cut in it corresponding to the external margins of the lesion. A six, or seven-inch spark current was employed, and a series of exposures was made, each lasting ten or fifteen minutes, until mild dermatitis was produced; then an interval of some days was allowed. After about fifteen or sixteen exposures a distinct improvement was manifest. The reaction produced was similar in kind to that of the Finsen System, but the dermatitis which was set up was said to be less marked in diseased tissues than in the healthy ones. Another case was shown in which, before treatment was commenced, there was absolute obstruction of the nose, but after a number of exposures the ulceration entirely disappeared, and nasal respiration became quite comfortable. Another case was referred to, in which X-rays, directed through the open mouth, had very favorably influenced lupoid ulceration of the palate and gums."

The advantages of combining exposures to the Finsen Method and X-Rays in alternation, were stated to be that the necessary daily exposure was shorter, and that it was much less costly, one method supplementing the other; and results were sufficiently good to encourage perseverance with the combination. (See Section on Photo-Therapy.)

Technic for Raying Lupus.—*Facial cases.*—Take pieces of sheet lead-foil large enough to cut off the rays from the entire head and chest. Cut a paper pattern to correspond with the area of the lesion as exactly as possible. Then *cut out the lead one-eighth inch smaller at the cutaneous margins.* Make two small holes at the sides for lace strings to tie back of the head, and if the nose does not participate in the treatment cut an outlet for breathing. The cause of many reported ill-effects on normal margins of cases treated has been:

1. *Too large a hole* in the lead protector. Or (Plate 174),

2. Failure to fit the edges of the hole in close relation with the lesion. Or,

3. The use of tin-foil or other metal in too thin layer for the given radiance. Or,

4. Disregard of the axial focus of the rays. Or,

5. Indirect contact between the edges of the metal and the dry and healthy skin.

Avoid all these faults of technic. Keep *the eyes closed* during treatment. Sit the patient in a chair in front of the tube. Bind a layer of surgical cotton over the entire lesion, making it thickest at the margins. Then tie the lead mask in position. If the breathing outlets are not in the field of treatment bend the lead out in front of the mouth to admit air. Press the marginal opening as closely as possible down to the covering of cotton. Next level and focus the anode so that *the axis of the rays will coincide with the centre of the lesion.* Use a tube giving not less than a good radiographic degree of radiance. Regulate the electric current to an even action of the tube. Place the surface five inches from the tube-wall. Then hook a grounding wire from a gas- or water-pipe to a convenient tie-hole of the mask and commence the exposure. Avoid the early rule of long daily exposures. Treat the part ten minutes, three times a week, at first. Watch for evidence of over-action. Lessen or increase the dosage as individual indications arise, according to suggestions throughout these chapters. Do not stop final treatment before full restoration is accomplished. An apparent cure may develop after such treatment ceases, but recurrence is likely. Manage the ordinary care of the case on rational principles. Those who have Static machines will find great assistance from special sprays as alternate treatment. (Plates 165, 166, 174, 175, 176, 179.)

Lupus patches on other parts of the body.—When neither protection of the hair of the head and eyes calls for special care the sheet of lead-foil may be prepared in the same way and tied on the part with the same care, but can be much less extensive, and with the air of the diaphragm the field of rays allowed to reach the part can be limited very nearly to the area of the lesion itself. Instead of sitting the patient in a chair the location of the lesion will often suggest a recumbent position. The remainder of the treatment is the same as described. Do not omit internal prescribing for the general condition of the patient when indications exist. (Plate 164.)

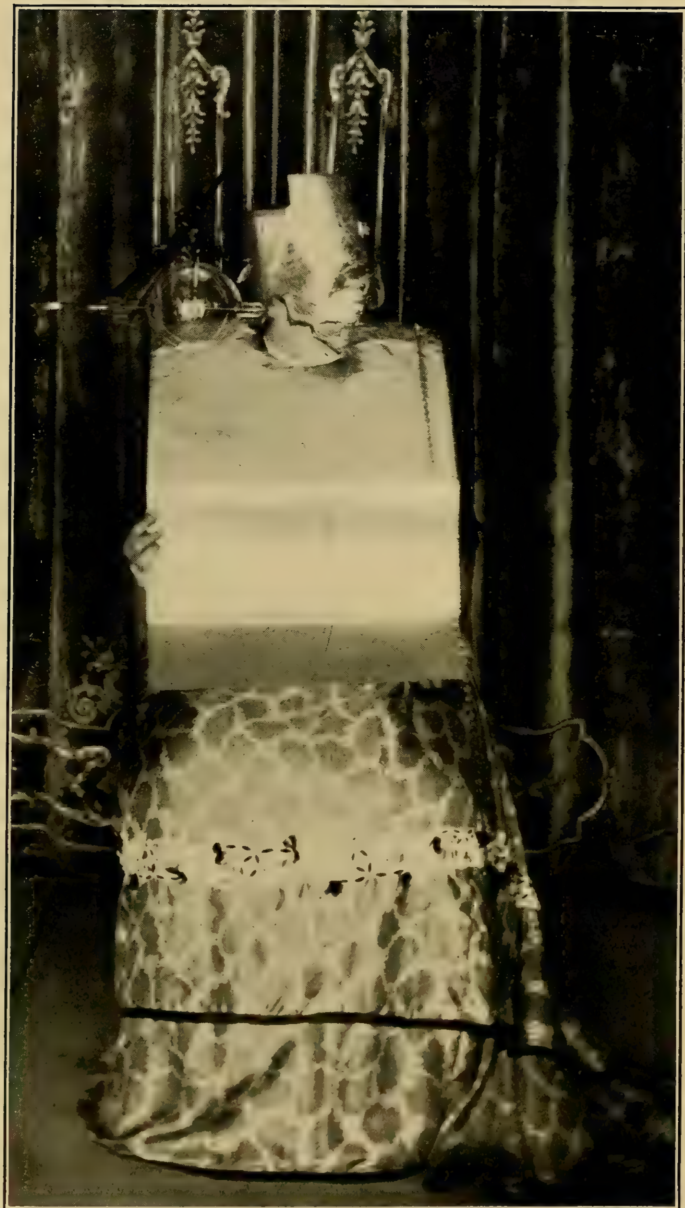


PLATE 173.—This plate shows one side view of foil-covered mask with space cut for treatment of side and chin whiskers on woman's face. The front shield protects the chest and shoulders during the exposures. The patient is seated on a revolving stool during treatment, the mask and shield grounded by the chain seen at right, the tube placed with its wall six inches from the tissues, and a total exposure of twenty minutes is divided upon the four areas of the two sides of the face and neck by turning the patient on the stool. Use a medium tube. Use the least current that will excite it properly. Repeat treatment three times a week. Watch for the first sign of irritation, and then wait till it subsides. Permanent depilation requires patience and careful treatment.

CHAPTER XL

X-RAY REMOVAL OF SUPERFLUOUS HAIRS

Results and Methods of Treatment.

Temporary and Accidental Alopecia from X-Ray Exposures.—It has happened in quite a number of cases that an undesired loss of hair followed either radiographic or therapeutic X-ray exposures about the head. It has grown in again in all reported cases. The *temporary* loss of hair from exposures made for other purposes is quite a different matter from treatment directed especially and persistently to the atrophy of the hair follicles. Clinical evidence thus far shows that *permanent* depilation is only brought about by use of the X-rays in a methodical manner. To those who meet with the undesired by-effect of alopecia in some other employment of X-ray therapy (its occurrence in radiography being now extremely rare) it is reassuring to feel certain that the lost hair will be restored. But, on the other hand, this fact lends uncertainty to the treatment of objectionable hypertrichosis. Up to the present time many practitioners have not distinguished between the management of the two cases, and without reason assume that permanent effects are impossible. For instance, a Western physician lately wrote to a medical journal as follows:

"For some time I have been seeing reports of the use of the Roentgen-ray for the removal of hair from the skin, all advocating this form of light-therapy for the purpose. My limited but very satisfactory experience in this line has led me to a conclusion opposing the opinions of the writers of the above-mentioned reports. I once made several long fluoroscopic examinations of a young boy, and also made a skiagram; another operator did the same, and some time later it was noticed that the hair on one side of the head, in a strip about half an inch wide, came out. It returned completely after a time. For about a year I was making various experiments with the X-ray, making many skiagrams of my left hand, and also using it as a test-piece in fluoroscopic work; a typical X-ray dermatitis resulted, marked by itching papules, swollen, cracked, œdematous skin, and loss of the hair from the back of the hand; I stopped using my hand in the way, and after a while complete recovery took place; there is just as much hair on the back of this hand as is on the other one."

In many cases it is important to know that a return growth may be confidently expected, yet it is equally important to observe that temporary effects are the result of temporary treatment or exposure, while permanent effects, when these are directly sought, are the result of the reverse of temporary exposures, and are secured only by long lasting and definite treatment directed to the end in view. That satisfactory results can be obtained has been conclusively established by many workers in different parts of the medical world. We will now consider the specific treatment of hypertrichosis and describe the technic.

Permanent Depilation by X-Rays.—Scattered profusely among the rich treasures of information in the two preceding chapters are many important allusions to this subject. The reader may study them in their proper context. The abundance of related experience permits us to abridge this chapter to a single further contribution—a study of dosage offered by Wood. When read in conjunction with Dr. Sharpe's exceedingly valuable study of the effective treatment of hypertrichosis in our chapter on skin diseases there will be little to add save the *technic.*

"A woman aged twenty-two consulted me in November, 1898, on account of a considerable overgrowth of hair on the face. The history given was that fourteen months previously one inferior turbinate bone had been removed, and that about three months subsequently the hair on her face, which had not been excessive, took on active growth. During the two or three months before her visit it had become conspicuous and excited comment. She was a healthy-looking fresh-complexioned brunette; bodily functions regular; nothing remarkable about the hairy scalp; hair on body said to be normal. On the upper lip, from a point half an inch from the middle line, and extending outward on each side for three-quarters of an inch, there was a moderately close growth of dark, rather thick hairs, mostly about a quarter of an inch long. In front of the ears there was a slight excess of hair, and this growth continued on each side, down to the angle of the jaws, the length of the hairs increasing to this point. On the chin the hairy growth was most conspicuous and disfiguring. From the point extending one inch upward, three-quarters backward, and one inch transversely, there is a groundwork of closely set down, and in addition numerous thick dark hairs, from one-eighth of an inch to one inch in length.

"It was decided to first treat this area, and to begin with the front part of the chin, the rest of the face and neck being protected with a lead-foil mask. The sittings took place, when possible, six times a week, and the duration of each sitting was ten minutes. The anode was between six and seven inches from the skin. The primary current was five amperes, and the number of interruptions between 250 and 300 per second. After fourteen exposures it was noticed that the darker hairs had lost some of their lustre, and a week later there was an obvious lessening in their number. The hairs shed were brittle and pale in color, with atrophic bulbs, while microscopically the normal striation was indistinct and the medullary substance appeared to be collected into separate nodes, with clear intervening spaces. During this period occasional reddening of the skin was noticed. Treatment continued till forty-five exposures had been given to the point of the chin, when the whole of the thick and downy growth had disappeared, except nine hairs, which remained at least a week after the total removal of the others.

"Mechanical interference having previously been avoided, it was now desired to ascertain the condition of these residual hairs. By making gentle traction on one it was found that it was really separated at its bulb, which was deeply placed, but was held by a more superficial part of the root-sheath. Therefore, the rest were left untouched. It was now clear that the object aimed at had been attained, and as the skin was somewhat reddened treatment was ordered to be given thereafter only to the under surface of the chin. This message to assistant miscarried, so that the front received a few more exposures, and a sharp dermatitis ensued, which, however, speedily subsided under simple treatment. Twenty exposures were also given to the under part of the chin, and ten consecutively to the cheeks. The result some eight months after cessation of treatment can probably be safely judged, since for three months there has been no change in the condition. The front of the chin, which received more than forty-five exposures, remains quite free from down and hair. The under surface, which had twenty exposures, is cleared of down, but within three months after suspension of treatment a few thick hairs returned. Their number, however, has not since increased, and they are so sparse that electrolysis is indicated for them. The cheeks, which had only a small number of exposures, temporarily lost their hair, but it has grown as before.

"It would seem then that for depilation ten short exposures are useless; that about twenty exposures will clear the ground for electrolysis, while some number between twenty and fifty will probably result in permanent depilation. It is to be expected that this number may be reduced by further experience, so that a treatment which *neither pains nor disfigures* may take its proper position in practical therapeutics."

Technic for Facial Depilation with X-Rays.—For small local superfluous hairs limited to one area cut out a lead mask as for a case of lupus and proceed in the usual manner. For more general hairy growths get a common " false face," such as are sold for about fifteen cents at toy stores. Fit it on the patient's face, and, with a lead pencil, mark on the outside of the mask the areas from which the hairs are to be removed. Take off the mask and cut out the parts as marked.

Next glue pasteboard wings at the sides and on top of this mask to extend beyond all tissues and normal hair needing protection. When dry and secure cut pieces of the " tea lead-foil, No. 1," mentioned in our chapter on Screens, of which every operator should keep a stock, and mould them on the outside of the pattern built up by the mask and its wings. In holes in the back insert two tie-strings to secure it on the head. Make a breathing opening for the nose and double the thickness of the foil over the parts that will be most exposed and need most protection during treatment. See Instruction Plate No. 173 illustrating device complete.

Next take a sheet of common card-board about two feet long and eighteen inches wide, cut out a half-circle at the top to fit around the neck, and cover the outer surface with a layer of the foil glued at the edges, to shield the bony prominences of the shoulders, the chest, hands, etc., during exposure. Once made and adapted to a patient these shields will last indefinitely and serve for all treatment the case may need. Next proceed as follows:

Connect a medium tube giving ample radiance in a holder which will permit free movement of position when the tube is in action. Seat the patient on a revolving chair in front of the tube and close to it. Have the tube ready to start into action and then tie on the face-mask; place the chest-shield in front of the patient so as to protect all necessary parts; have the patient support it by her hands held low down at the sides out of reach of the rays; hook the grounding chain over both shield and mask, and turn either side of the face toward the tube to begin the treatment. Place the tube so that the axis of the rays is square with the exposed area of the face, with the tube-wall about five inches from the skin. Turn on the current and light up the tube. The two sides of the cheeks and the two sides of the chin and neck may be considered four areas to successively bring into the direct field of the axis of the rays, for oblique rays are so much less effective that they do not constitute treatment. Have the patient first hold one side of a cheek steadily in the field of rays for five minutes, then without stopping the tube direct her to turn the face so as to bring one half the chin into the field, and, while raying this region, shift the level of the tube as needed to reach all parts, and also have the patient raise or lower the head and chin according as the under or outer surface is being treated. In five minutes make another quarter turn, and finish a total séance of twenty minutes with the rays on the last area.

Keep the tube evenly excited all the time, and turn the patient with care against her getting too close to it. Some shifting of the position of the tube is required to reach under the chin. One level will not treat all the areas. Especially avoid letting the patient drop the chin carelessly too close to the tube, as this region has thin tissues which irritate rather easily. Also note that a stiff high collar, such as some wear, will be rubbing on the under surface of the neck all the time, daily, and create a predisposing condition of irritation. This will easily tan a brown or get up an erythema. The safeguard is in maintaining distance and not letting the tube get up to one or two inches from the skin. At the close of the sitting remove the tube out of the way, take off the mask and shield, and, if any irritation arises, remove it with a sedative application. This is usually an emollient ointment prescribed by the physician, but may be the sedative static breeze as taught by the author.

Repeat exactly the same exposure every second day till either some slight tanning effect, or reddening, or other sign of action appears, and then stop all treatment for a week to observe the cumulative effects. If no action appears visible after, say, ten treatments stop anyway. There ought to be no irritation with a careful dosage, and the patient may think that nothing is being accomplished. She must understand, however, that safe action is slow action, and results will take time.

After the week of tentative rest resume treatment as before, and give another series of about ten treatments with a week's rest at the end for observation. If more than merely nominal discoloration of the skin has occurred increase the distance of the tube two or three inches. If any sign of erythema appears reduce the length of each exposure after a rest till all irritation disappears. When the skin begins to feel somewhat stiff and sore, and, finally, when bleaching of the hairs can be observed, yet having avoided dermatitis, the first stage of treatment is nearing an end. Continue sittings till most of the hairs fall out naturally as the patient rubs the face with the towel after washing as usual. Do not pull out any hairs forcibly at any time. At intervals of about one month make a series of three or four exposures to abort any tendency to return. Gradually lengthen the interval as time shows the results to be complete, and, finally, stop all treatment with instructions for the patient to report for a few sittings if in future time any new hairs appear.

Regulate the current to work the tube well without an excess of electrical action. Do not force a tube after it becomes resistant, but take another and let the first rest. After the early series of exposures watch for the appearance of incipient itching, or redness, or any sign that the skin has been acted on. The irritability of the tissues which discloses these symptoms is controlled in the following manner better than by any emollient unguent. Remove the tube after the depilation treatment and seat the patient on the static platform connected by a metallic contact with the positive prime conductor. Ground the negative pole to the water-pipe or gas fixture. Ground a polished brass-point electrode. Start the machine into just sufficient speed of the plates to give a strong breeze without liability of spark. As the plates begin to turn, quickly bring the point of the electrode up to within two inches of the bare surfaces of the face which have been X-rayed. Gently move the breeze over all the parts till they are cool, soothed, and refreshed. Five minutes is sufficient to give complete relief. When the condition has advanced to the pains, stiffness, and other mild symptoms described by various writers in previous chapters, this sedative application will delight the patient by almost magically restoring the feeling of the face to normal. It can be applied after each X-ray exposure when needed. The method must conform to the author's teachings in order to secure the effects. An irritating spray must not be used.

CHAPTER XLI

CUTANEOUS CANCER AND RODENT ULCER

Reported Results of X-Ray Therapy. Methods Employed.

A very large number of medical men are now engaged in testing the effects of X-ray discharges on *superficial* forms of cancer. Few final reports have yet reached print. Palliation may encourage the patient, yet deep *malignant* disease has not won its name without reason, and if X-rays prove less potent than some now hope, it will be cause for thankfulness if they improve upon the knife. That they are demonstrating an important action which deserves the fullest development and test cannot be doubted. From private sources we hear of remarkable results now in progress in various parts of this country in cases of cancers and sarcomas, and, though conservatism awaits on time for the announcement of any radical conclusion, we think that the published selections here presented will be deemed *under-estimates* of X-ray value by workers with the matured technics which the future has in store. Statistics and reports of the past regarding the X-ray treatment of cancer should not be accepted as the measure of future results. Some cases were treated too timidly, some too actively, some stopped treatment much too soon, some practitioners had not yet the experience to direct the action, and, perhaps, most men who look back to their earlier cases now feel that they know how to do better. Many partial failures with a new remedy are due to faults in method, and with an intelligent selection of the case, a skilled management of the treatment, and the essential persistence in treatment till not only surface indications have been met, but the patient has really had all the benefit that can be given him, we shall in future see greater success and more permanent effects than many now suppose possible. The author is convinced that many operators have failed to employ adequate dosage and sufficient persistence. Dosage is as important in all forms of physical therapeutics as it is in drug therapeutics, and when administrations can be based on scientific dosage results will improve. As there is practically no risk whatever in attempting to relieve and prolong life by this method, we urge the careful study of this chapter by all physicians and surgeons and a judicious comparison with the results of operative interference.

We first submit for study Chamberlain's explicit report of May, 1901, on the " X-Ray Treatment of Cancer " in his practice.

" The object of this paper * is to report a few cases of cancer treated with the X-ray, and to make a few deductions therefrom, in the hope that others may be influenced to continue the experiments and assist in robbing one of the most dreaded diseases of some of its horrors.

" The following cases were treated with the ray generated in a Monell tube connected with a ten-plate Wimshurst Static machine. Tubes of varying vacuum were used, from one so soft that the ray could barely penetrate the hand, to one so hard as to give a ray of the greatest penetrating power.

" Most of the treatments, however, were given with the highest vacuum or so-called hard tubes. The distance of the tubes from the parts treated varied at times from three to ten inches, and the time of exposure from three to ten minutes. *The best results were obtained with high tubes at a distance of four to five inches, treating for six minutes at each exposure.* The frequency of treatments varied from daily to twice a week, until some effect was noticed. This effect, in the case of an open sore or mucous surface, consisted in the appearance of an exudation, grayish in color, which, when stripped off, left a bleeding surface. In the cases of a skin surface this effect consisted in the appearance of a redness which is described as being from a dermatitis; in none of my cases, however, was this so-called dermatitis accompanied by any itching or burning sensation. The effect referred to did not appear before the eighth day following the first treatment, in some cases it was delayed for three weeks; the average, however, was about the tenth day. As soon as either exudation or redness appeared the treatments were reduced to three or four a week.

" As far as possible the healthy tissue surrounding the growth was protected by lead rolled very thin, or four thicknesses of tin-foil such as is used by florists. When hypertrophic granulations were present they began to melt away about the time the exudate appeared, and a healthy healing line usually appeared within a month.

" When hairy parts were exposed the hair fell out with one exception; but in all cases where sufficient time has elapsed, the hair has grown again. In cases of *open* secreting surfaces, the secretions were rapidly lessened; but in one case, where the deep cervical glands were septic the formation of pus seemed augmented by the application of the ray, from which I argue that the ray is not germicidal.

" Case 1.—A physician, seventy-five years old, who reported his own case. He had an epithelioma which began as a scale on the skin

* Journal of Electro-Therapeutics.

between the angle of the mouth and the wing of the nose on the right side. Finally there followed a deep open sore, which refused to heal and was removed by operation. A similar growth started at the wing of the left nostril, which increased, as did the first one, and was also removed. This one returned and was again removed. It returned again, however, and ate away almost half of the nose, including the cartilaginous portion of the vomer, a portion of the upper lip, a large hole in the left cheek, which extended to the malar bone and was very near the left eye. It invaded the mouth and ate away a portion of the gums on the left side, so that it was impossible to masticate solid food. The entire sore surface, including the inside of the nostril, was covered with easily bleeding fungous granulations. After about six weeks of treatment all pain and burning had ceased, and there was positive evidence of healing. In four months' time he had gained about twenty pounds of flesh, was able to eat solid food again, and the sore was healed with the exception of a small space over the edge of the vomer and on the maxillary bone above the incisors. At these points the cicatricial tissue was so thin and the blood supply was so limited that the surface seemed ready to break down. Occasional mild treatments were continued for some weeks till this surface healed over. My last reports from the doctor, some four months later, were that he remained well, had resumed his practice, and had bought himself a Static machine for the purpose of treating similar cases.

"Case 2.—A man of sixty-five years with an epithelioma on the left temple, and involving the left orbit, having destroyed the lower eyelid and eaten a hole into the nostril at the site of the inner canthus. This patient had submitted to several surgical operations and the application of numerous cancer plasters. I was compelled to remove the eyeball to save the other eye, in which sympathetic ophthalmia had begun. The accompanying photograph, marked Case 2, shows this patient's condition as he came to me, and also his appearance after the sore was healed. The white patch on the side of his nose is a piece of cotton placed there to cover the hole in his nostril. The patient remains well to date also.

"Case 3.—A woman, aged fifty-four, suffering from an inoperable cancer of the cervix. She had an offensive leucorrhœa, was anæmic from hemorrhages, which had been recurring for the last six months previous to her consulting me. She had passed the menopause one year before the first hemorrhage occurred. Her husband, a physician, was giving her morphine to relieve her pain.

"*Ten-minute treatments were given daily through a Ferguson speculum.* After eight treatments the characteristic exudate began to appear on the cervix, the offensive discharge was much decreased (though there had been no change in the local measures used), and she did not have any more hemorrhages from that time on. After the twelfth day she had treatments three times only per week, and of five minutes' duration, which was increased in a few days to seven and one-half minutes each. Her pain was very much relieved, and the abdominal distention disappeared. She unfortunately had the morphine habit, so that the opiate could not be withdrawn at once; but her husband was withdrawing it gradually. After two months and ten days' treatments had been given, and we were very much encouraged by so many favorable signs, our patient suddenly developed signs of cerebral embolism, from which she succumbed about two weeks later. She had no renal or cardiac lesion, and a question still remains whether the source of the embolism was in the uterus and from too rapid disintegration of the cancer caused by too vigorous treatment, or whether the hypodermic needle struck a vein.

"Case 4.—A man, aged sixty years, with a smoker's cancer of about four years' duration. The growth began on the left side of the lower lip. Two years ago glandular involvement appeared under the right submaxilla. This patient's condition when he presented himself for treatment may be seen at a glance by referring to the accompanying photograph, marked Case 4, and the effect of the X-ray treatment on the case is also to be seen. All the mouth, except a small portion of the upper lip, right side, has been eaten away; there was almost universal involvement of the lymphatic glands of the neck, the inferior maxillary bone has been eaten in two at the chin, so that the two sides move independently. The glands of the throat were so indurated and enlarged as to threaten suffocation by pressure. The whole face was swollen; and hypertrophic granulations filled the wound and everted its edges. The treatment has entirely disposed of the hypertrophic granulations, removed the swelling from the face, relieved the dyspnœa, inverted the everted edges of the wound, has relieved the pain, and allowed the general condition to improve very much. Time only will tell whether the case will be cured, a result that I hardly yet dare to expect. However, if nothing more is accomplished than what is here demonstrated, the treatment cannot be said to be a failure. The case is still under treatment.

"Case 5.—A man, aged thirty-nine years, noticed a hard scale on his cheek six months ago, which he picked off. The scale soon reformed and grew so as to form a red papule with signs of breaking down in the centre. There may be a question as to the diagnosis of this case, but it seemed sufficiently clear to me to include in this report. Three treatments a week for six weeks resulted in the entire disappearance of the growth, and now, four months later, there is still no appearance of its return.

"Case 6.—A woman, aged thirty-two. Three and one-half years ago the crown of the wisdom tooth on the right side of the lower maxilla broke off, leaving a ragged edge. This tooth irritated the side and base of the tongue, finally resulting in an ulcer which has resisted every effort to heal, and has been repeatedly diagnosed as cancer of the tongue. There was a small glandular enlargement in the neck near the base of the tongue. One and one-half years ago the sore was thoroughly curetted, with temporary benefit. Afterward plasters were used. There was considerable pain. Twelve weeks' treatment gave considerable relief from the pain and reduced the size of the sore somewhat; but the patient became restless and quit the treatment.

"Case 7.—A man, aged fifty-seven years, having a smoker's cancer of two years' duration, which had eaten away the entire lower lip and encroached rather close to the chin, with a secondary growth under the chin. This case showed evident signs of healing at first, but of late there is a tendency for the ulcerative process to extend along the inside of the cheek. All we have gained in this case is relief from pain and suppression of all tendency to form hypertrophic granulations. This case is still under treatment.

"Case 8.—A man, aged forty-four years, whose photograph accompanies this report, being marked Case 8, presented a large ulcerating growth on the left side of the face, three inches in diameter, also a large secondary glandular enlargement below the ear and a small one under the chin. The eye was much inflamed, and a small nodule with an ulcerating apex involved the lower eyelid. This cancer resulted from the kick of a horse four years ago; but its growth has been almost entirely during the last two years. A year ago an extensive operation was done in an effort to eradicate the disease, and this was followed by several secondary operations with the same object in view. All failed, however, and plasters were resorted to without success. When this patient presented himself he could not stand or walk alone, but was assisted by two people. His pulse averaged 130 beats per minute. He was extremely emaciated and suffered tortures from the painfulness of the disease, relying upon antikamnia and codein in large doses for relief. In spite of extreme cleanliness the sore was very offensive and was discharging freely. Now, after five-months' treatment, this man walks many blocks a day without assistance, requires no opiate, is free from offensive odor, and the sore has healed to a marked degree, as shown in the accompanying photograph.

"Case 9.—A man, aged sixty-four years, had an epithelioma on the ala nasi of four years' standing. The growth measured one inch in length and one-third of an inch in width, and was separated from the inside of the nostril by tissue hardly thicker than tissue-paper. Two-months' treatment healed the sore, which I am sure remains healed, or the patient would have been back again.

"Case 10.—A man, aged about fifty years, had several scabbed spots on his face, with the history of removal of the first one that appeared with the knife. This soon recurred, with others, and on second removal the specimen was examined with the microscope and pronounced epithelioma. I gave two ten-minute treatments to two of these spots, with an interval of a day, and let him go South to his business with directions to return in a month. He did not return till four months had passed, however, when I found the two spots treated were clean and healthy. I then treated the remaining spots in a similar manner, and have not heard from him since.

"Case 11.—A man, aged fifty-nine years, had an epithelioma of the lip which started about two years ago. It never amounted to much till a year ago, when he consulted a physician, who said it was cancer, and should be removed. He accordingly submitted to an operation. About a month later it reappeared, and he had it immediately removed, only to have it recur in about two weeks. He had it removed the third time, and it recurred in less than a week; so he refused to have any further operative work, but went to a cancer hospital, where chloride of zinc plasters were used. After some five-months' treatment in that institution the growth had progressed rapidly, so as to involve the right side of the lower jaw as far back as the angle, the inner side of the cheek, the cervical glands of the neck very extensively and almost as low as the clavicle, underneath the chin, and there was some glandular involvement on the other side. When presented to me he had been living some months on liquid food, and the septic condition of the cervical glands was so bad as to cause a daily rise of temperature to 101°. There was constant oozing of large quantities of pus from many sinuses; there was a large hole in the right cheek with everted edges, from which protruded a fungus mass of unhealthy granulation-tissue. The pulse in this case averaged about 110 per minute. Three-months' treatment resulted in the disappearance of the fungus granulations, reduction of the swelling of the face, relief of the pain, and some temporary increase of strength. The treatment seemed only to increase the formation of pus in the tissue, however, which interfered materially with the progress of the case. This patient finally succumbed to the prolonged suppuration.

"Case 12.—A man, aged thirty-nine, had his left testicle injured four years ago. The organ had pained him at times ever since. About a year ago he noticed it was growing larger quite rapidly. Last March the organ was removed and examined microscopically and pronounced to be a carcinoma. Four months later the patient had a recurrence of the pain, and examination revealed a nodule in the inguinal canal on the cord. This nodule seemed to be attached to the surrounding tissue, and was declared by the surgeon who had operated in the first place, and by two others in consultation, to be a recurrence of the cancer. The patient, being discouraged by the failure of the first operation, refused to have a second, and decided to try the X-ray. After six-weeks' treatments of three per week for six minutes, each at five inches distance, the nodule has entirely disappeared, as has also the pain. The surgeon above referred to examined the case after the treatments and concurred in the opinion just stated.

"Case 13.—A woman, aged sixty-five years, was annoyed by a small scale which appeared on her cheek in front of the left ear. This scale itched and burned so she scratched it off. It immediately

PLATE 174.—Instruction Plate showing "How not to do it." For a small lesion of the lid do not cut hole in mask larger than the whole eye. Do not lay the metal directly on the skin. Photographed for this work by Dr. G. Stopford Taylor, Liverpool, Eng.

PLATE 175.—Epithelioma of Nose. This pair of Instruction Plates shows the face without shield to teach the relation of tube, and the patient completely prepared for lighting up the tube. The surface of lesion has been scraped to facilitate action of rays. Position of tube focussed on lesion with glass wall a hand-breadth distant is well shown. Then a layer of surgical cotton is placed over the part, and the shield tied on. Exposure is then made as taught in the text. Photographed for this work by Dr. G. Stopford Taylor, of Liverpool, Eng.

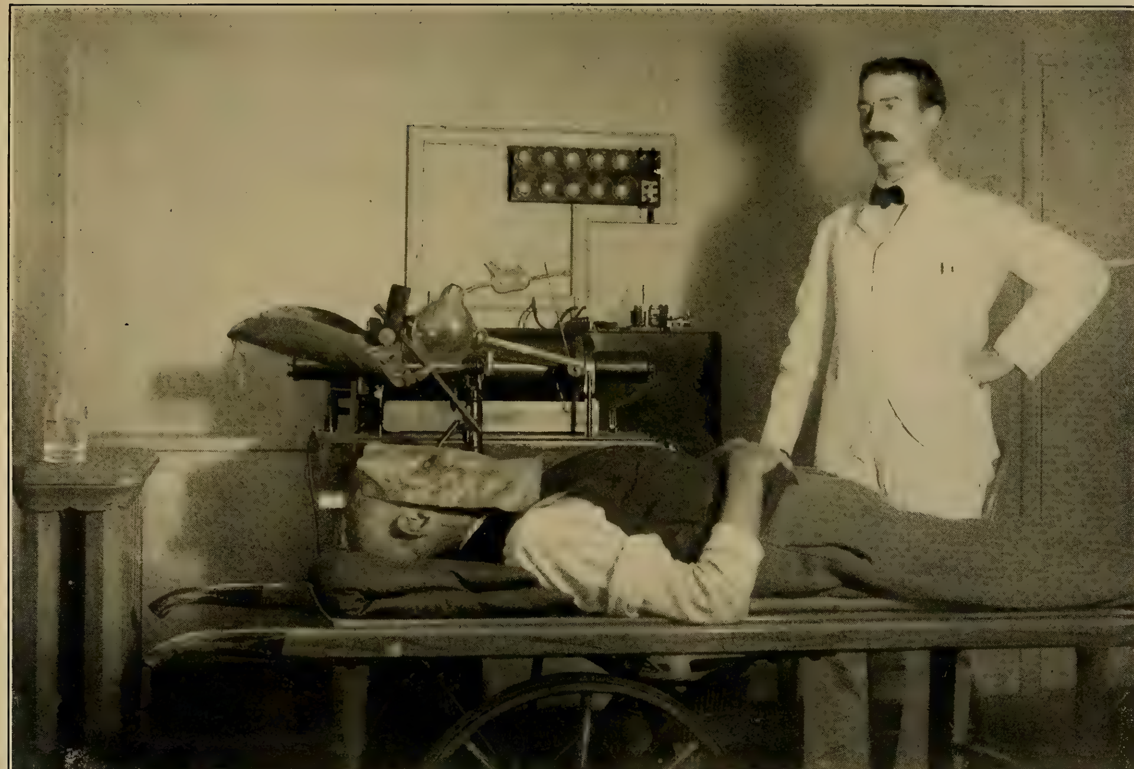


PLATE 176.—This Instruction Plate shows the technic employed in the X-ray treatment of the two cases of cancer pictured in the next plate, and reported by Dr. Pfahler. See text for description.

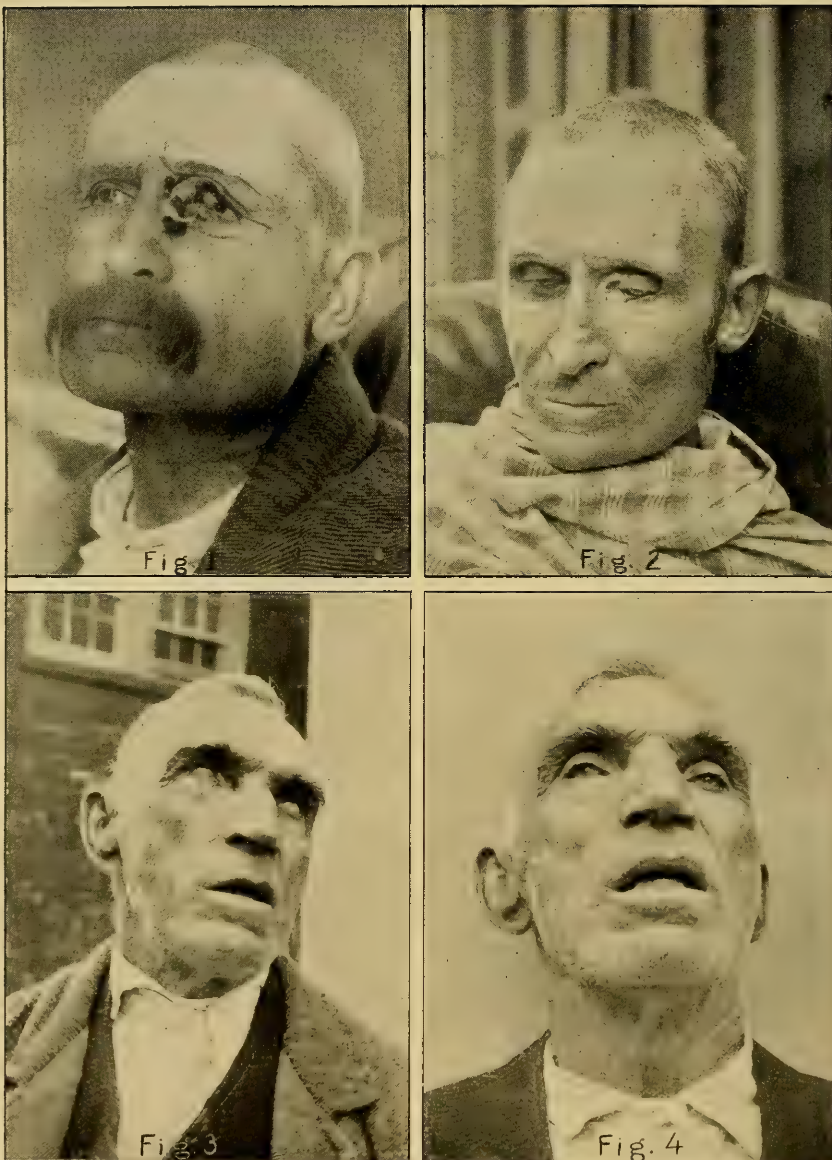


PLATE 177.—Photograph No. 1 shows the extent of the lesion in Dr. Pfahler's second case at the time X-ray treatment was begun. No. 2 shows the reduction of the lesion obtained in thirty-four exposures before the patient died from complications. Photograph No. 3 shows lesion on right lower eyelid of Dr. Pfahler's third case of epithelioma before treatment was begun. Fig. No. 4 shows the result of treatment.

returned, to be scratched off again. After repeated removal and recurrence it developed into a small nodule the size of a dime, with a disposition to ulcerate in the centre; and the itching now amounted to pain. There was a small glandular enlargement below and in front of the ear. About a dozen treatments, given three per week, resulted in the entire disappearance of the nodule without scarring the surface, and there is no sign of return, though four months have passed since treatments were stopped.

"I pass to the following deductions from the cases reported, viz.: that the application of the X-ray is capable (1) of healing epithelioma of the face without deep glandular involvement; (2) in some cases at least, of relieving the pains of cancer; (3) of destroying the exuberant granulations of cancers which are the source of much offensive discharge as well as increased disfigurement; (4) of removing incipient epithelioma without production of scar; and (5) of accomplishing all these things without pain."

Johnson and Merrill reported as follows:

"*We are firmly convinced that, by means of the proper application of this agent under conditions of no practical discomfort to the patient, we can bring about the painless removal of slow-growing epitheliomas.* These growths, especially when they occur on the face, are very disfiguring; if allowed to progress they produce a condition loathsome in the extreme. Treatment of such cases by the X-rays leaves a remaining defect that is incomparably better in cosmetic results than that which must accompany extirpation by knife or caustic. Furthermore, our experiments lead us to believe that even in inoperable cases of carcinoma attacking superficial parts, *we may give great relief from pain and can even slightly prolong life. If we can dispense with the use of opiates in this class of cases and free the patients from pain while leaving the intellect clear and digestion undisturbed, we have made a great improvement in the therapeutics of this condition.*

"To substantiate our statements we offer the following reports of cases already treated.

"Case 1.—Mr. G., aged forty-five. His father died of cancer of the lower jaw. Eight or ten years ago he noticed on his left cheek a small pimple. In 1894 the diseased area was removed and the actual cautery applied. A year later the ulcer had returned, larger than before; a second operation was performed with apparent success, but in three years the disease had returned in full force and a second centre had developed on the right side of the nose. The several surgeons who had had charge of the case pronounced it epithelioma.

"The applications with the X-ray commenced September 6, 1899, and continued until October 9th. The exposures were made every other day until fifteen were given, ten to the nose and five to the cheek. A marked reduction in the quantity of the discharge was the first result noted. This appeared in about three days. Then the scab of dried secretion which formed over these surfaces would form more slowly and remain adherent longer each time.

"The last exposure, made with an extremely active tube, set up a severe dermatitis, though the application lasted only five minutes. The surfaces became inflamed, the discharge profuse and watery; a typical X-ray burn was produced. Treatment was suspended for six weeks. At the end of that time a healthy cicatrix had formed over both areas. When last seen, six months after the last exposure, smooth white scars slightly depressed, invisible at a distance from the patient, had replaced the original ulcers.

"Case 2.—Mr. I., aged forty-eight, applied for treatment February 17, 1900. Five years earlier the tip of his nose was accidentally scratched and, while the place was still raw, it was bitten by a fly. The part immediately became very painful and began to swell. Thinking that he had been poisoned, he consulted a physician at once, with the result that vigorous treatment with chemical caustic continued from that time until the above date. His physicians diagnosed the disease as lupus vulgaris.

"A small piece of the edge of the ulcer of the right side was removed for a microscopic examination; the result proved the disease to be an epithelial cancer and not lupus.

"We began treatment at once, exposing the right side of the nose on every alternate day until it had had three exposures of an average length of six minutes each. One week later the left side was given two treatments. An interruption of three weeks followed, during which time a mild inflammation set up in and about the cancerous tissue. On March 31st the second photograph here reproduced was taken. As the left side had not completely healed over it was given three more exposures. On April 14th, the entire external surface was covered with healthy skin. A small diseased centre still remained, however, about the perforation in the septum. Treatment at this place commenced May 12th. The area is now progressing rapidly toward healthy tissue, though sufficient time has not yet elapsed to effect a complete cure.

"The accompanying photographs, taken February 17th and March 31st, indicate better than any description the original condition and the improvement.

"Case 3.—B. C., aged sixty. Some time in the latter part of the summer of 1899, he noticed a small abrasion about the middle of the lower lip at the junction of the skin and mucous membrane. This became painful and spread steadily until the patient applied for treatment February 21, 1900.

"The original condition was as follows: 'At the middle of edge of the lower lip is a small tumor, almost spherical in shape, 2.5 centimetres in diameter, extending about equally over the mucous and skin surfaces. Where the surface is not covered with a crust, it discharges a bloody, foul-smelling serum. The patient complains of constant pain in the diseased part.'

"A small piece removed for microscopic examination proved it to be epithelioma, as is shown by the accompanying photomicrographs.

"Treatment was instituted at once. The growth was exposed to the action of the focus tube on every second day for four exposures. There followed an intermission of eighteen days to determine the severity of the dermatitis produced. March 20th treatment was renewed and three additional exposures were given.

"The results noted are, first, a disappearance of pain in the lip which followed the first treatment and remained permanent; second, the quantity of the discharge was lessened and the discharge itself lost its offensive character; third, very little dermatitis was produced and the tumor did not diminish in size. The patient did not return for treatment after March 23d. Improvement in this case consisted in the relief from pain and from the offensive discharge.

"Case 4.—Mrs. S., aged thirty-three. After her third child had been weaned she noticed a tumor in the right breast which rapidly increased in size. Her physician advised removal and excised the entire breast in the early part of the year 1899. A few months later the tumor returned and a second operation was necessary. This also was unsuccessful. Removal by paste was then undertaken, and these applications continued until the patient came to us in April, 1900.

"The following observations were then made: 'The patient is weak and anæmic, has no appetite, and complains of much pain in and about the scar of the first operation. This extends from the axilla to the sternum, which, with the surrounding skin, is bound tightly down to the ribs beneath. Above this scar at the axillary end there is a small nodule which may be due either to a diseased gland or to the puckering of the tissue in the contraction to form the scar. This had escaped the patient's notice and was not observed until we called her attention to it. A little internal to the mammary line above the scar is a tumor, about five centimetres in diameter. This mass, like the scar-tissue, is tightly bound to the ribs, and while not painful to the touch is a centre from which at intervals shooting pains radiate. This tumor has sharp, well-defined margins. Below the scar, on the sternum, is an open ulcer from which a tumor is said to have been removed by paste only a week previous. This application had been made three times here without effecting a cure. There is, however, a scar slightly external to this place, from which a tumor is said to have been successfully removed by this process.

"Treatment began over this open place first, then over the large subcutaneous tumor, and, lastly, over the nodule at the anterior border of the axilla. The time during which the patient has been under treatment extended from April 9th to the time of writing, May 21st.

"During this interval the patient has experienced absolute relief from pain, has increased in weight and has improved in general appearance. The open discharging ulcer has been changed to a cicatrix, over the centre of which a dry scab one centimetre in diameter has remained for twelve days. The original opening was four centimetres in diameter. The margin of the large tumor has softened, and its diameter has reduced one centimetre. The tumor also seems to be less prominent. No change has yet been observed in the nodule owing to the shortness of the time it has been under treatment. The entire relief from pain and the generally improved condition of the patient would seem to justify the treatment, though the report at this time is necessarily incomplete. Treatment will continue for the present.

" Case 5.—Mr. P. C., aged seventy-two years. He says his present trouble dates from a razor cut, of the external nasal septum, inflicted several years ago. This would not heal, for he kept continually scratching and rubbing it, on account of its intense itching. His nose before the onset of the disease was thin, sharp, and straight, but it has gradually taken on the bulbous, knot-like appearance, shown in the accompanying photograph. The external surface of nose appears slightly reddened and presents five ulcerating surfaces, which are only slightly depressed. They discharge a considerable quantity of purulent serum, having a disagreeable odor. A section taken from the nose for microscopic examination proved it to be a typical epithelioma. Patient complains of great itching in nose.

" Treatment began at once, July 1, 1900, with an exposure of the whole end of the nose for seven minutes to the most intense burning ray we could produce. Although a decided dermatitis appeared by the end of the week, treatments of twenty minutes each were given on July 7th, 9th, 12th, and 16th. The whole surface exposed soon developed into one large discharging ulcer which did not commence to granulate over for three weeks. By the end of August the nose had become entirely covered over by new skin and very much diminished in size. The second photograph was taken November 2d, just four months after Fig. 6, and shows an apparently complete return to the normal.

" Case 6.—Mr. M., aged fifty-five, presented himself for treatment August 3, 1900. He had a small superficial ulcer four to five millimetres in diameter on the tip of his nose. This presented a slightly depressed, easily bleeding surface from which exuded a small amount of serum. He said that for two years this had been treated by dermatologists and others without any beneficial result. In fact the place became progressively larger and worse. It never discharged more than enough to keep it covered with scales, or later a scab. A portion for microscopic examination was not obtainable, but the symptoms, history, and appearance all warrant the diagnosis of epithelioma.

" Treatment was commenced August 3d, with an exposure of seven minutes. This was followed by seven-minute exposures on

PLATE 178.—Case treated by Dr. F. H. Blackmarr, Chicago. "Mrs. G., age fifty-two, scirrhus cancer of the right breast. Photograph shows the hopeless aspect of case. Under treatment for one month; X-ray exposures; only soft tube used; severe burn resulted. Hardened area disappearing; lymphatics still involved. Marked improvement as far as pain, discharge, and odor is concerned. Photograph shows method of support of arm for treatment of glands in the axillary region. Mask hanging upon standard at the left of patient and above coil, is my form of lead mask for small areas of exposures, closing all the openings except the small one, and as I desire to enlarge opening for larger areas, I simply turn the disks of lead from the centre upward. Treatment of this case averaged twenty minutes daily for one week, fifteen minutes daily for the second week, and ten minutes for the third week, gradually shortening the time of exposure until 'burn' develops, or marked improvement has become evident. The position of the tube is not shown in the photograph, but should be placed within six inches of the breast."

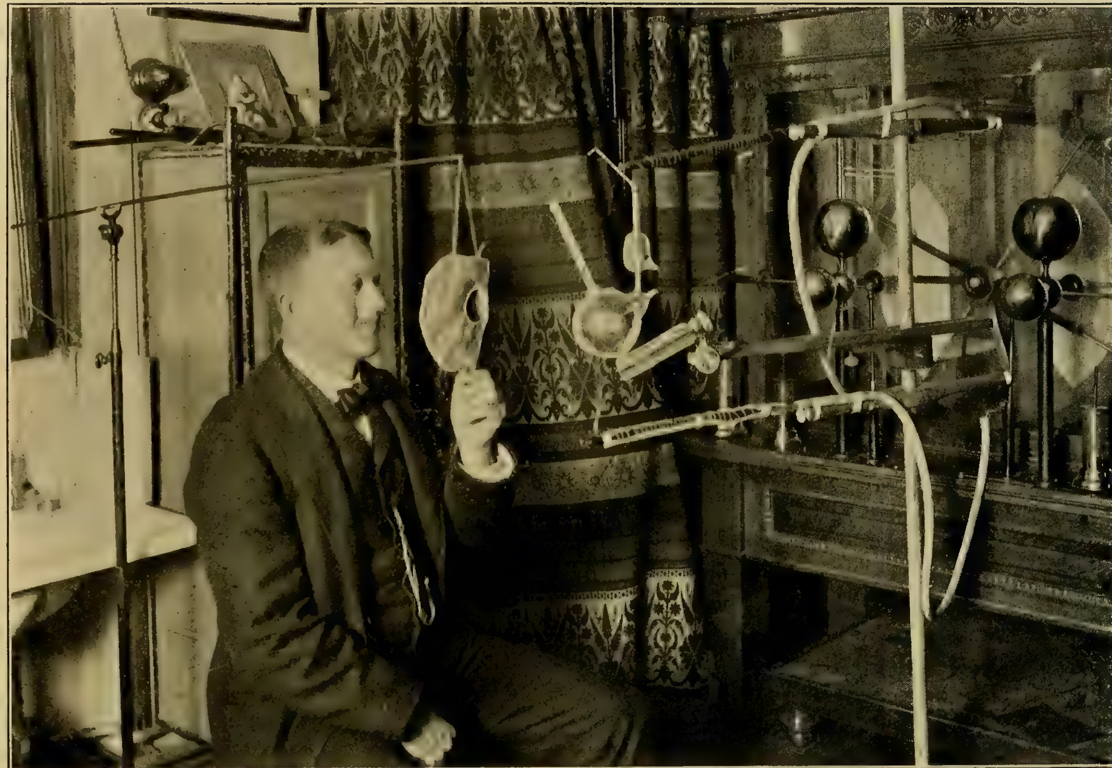


PLATE 179.—"Mr. H. E. S. Case referred to me two years and two months ago. Epithelial cancer of the face and nose; destruction of right side of nose and upper lip, involving a very small area of the floor of the orbit. Still seems to be cured." (Blackmarr.)

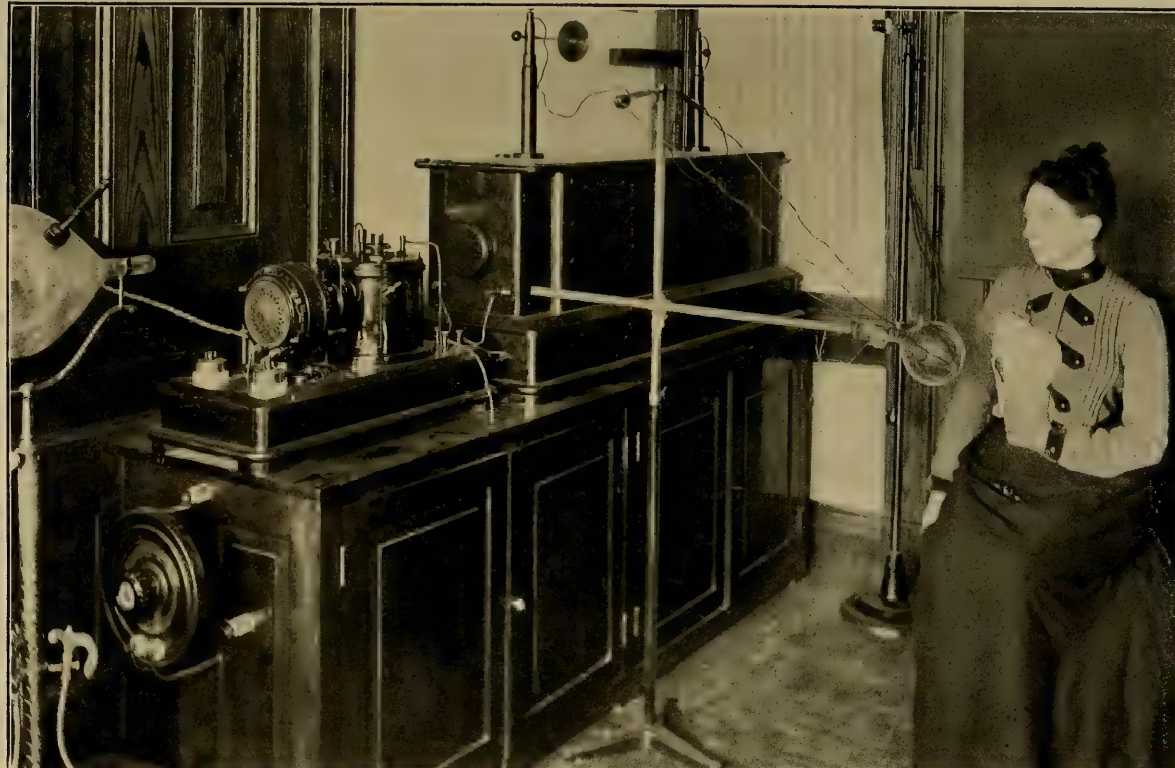


PLATE 180.—"Scirrhus Cancer of the Breast. Had been operated on unsuccessfully. Began X-ray treatment July 27, 1901. Improved from the start. Last treatment recorded September 13th. The hardened areas disappeared, but the lymphatic glands were not improved perceptibly." (Blackmarr.)

each of the following dates, August 8th, 11th, and 13th. The part of the nose treated reacted promptly, but the inflammation produced was not severe enough to cause profuse discharge or slough. The surface promptly healed over, and two weeks later no remnant of the disease was apparent. There has been no sign of recurrence up to the present time, November 23, 1900.

"At the time of exposure the patient experiences no uncomfortable sense of heat. In fact, there is no sensation whatever. The time required for the treatment is not burdensome in view of the palliative results which occur almost immediately and the permanent benefit obtained in a few weeks. The photographs of case two were taken only six weeks apart. The relief from pain followed the first treatment in three cases. This is surprising when one considers the persistent character of the pain in these cancerous growths. Cases one and three show far better cosmetic results than could have followed radical surgical interference."

We are able to supplement this report by a personal letter from Dr. Johnson, written July 24, 1901, kindly giving the author the following information: "We have since treated several additional cases, with results that are encouraging to us. Of the six cases reported in December, 1900, Nos. 3 and 4 have since died; Nos. 1 and 2 are still under occasional treatment for outbreaks in new localities near the original ulcers. Nos. 5 and 6 are still completely well, with no sign of recurrence."

Six cases of cancer have been treated by Dr. G. E. Pfahler, Assistant Chief Resident Physician and Skiagrapher to the Philadelphia Hospital, who reports three of them as follows: *

"Case 1.—A white woman, aged seventy, admitted to the hospital July 5, 1900, for senile dementia. Family history negative. Twelve years ago a small sore developed on the bridge of the nose under the bridge of her spectacles. A crust soon covered the sore. Each time it was removed and reformed the ulcer was a little larger. This increase in size became more rapid during the last year. It was especially noticeable after her admission to the hospital. Her mental condition improved, and she was transferred to the skin ward. The growth on the nose was diagnosed as cancer by the visiting surgeons and dermatologists, and was considered inoperable. After consultation with the dermatologist on duty we decided to expose the growth to X-rays. At this time the cancer involved the entire base of the nose, was 3.5 centimetres in diameter and extended into the inner canthus of both eyes.

"Treatment was begun February 12, 1901. All of the face but the cancer was covered with a lead-mask. Ten-minute exposures

* From "Treatment of Cutaneous Cancer by the X-Rays," read at the second annual meeting of the American Roentgen-Ray Society, Buffalo, September 11, 1901.

were made every second day with the part ten inches from the tube. The current to the primary of the coil was ten amperes. The tube was a self-regulating type. It was adjusted for a 'soft light' to a vacuum corresponding to a parallel spark-gap of from four to six centimetres. The first effect was a drying of the secretions, noticeable after two days. Then a crust formed and the edge assumed a healing appearance. After two weeks the ulcer began to heal from the edges and was one centimetre less in diameter. In three months the ulcer was reduced to five centimetres in diameter and was replaced by healthy scar-tissue except at the inner canthus. In this region it was much improved, but not yet healed. I regret that a photograph was not made at this time. The patient then had an outbreak of insanity and treatment had to stop. Her general health also failed. We were again able to resume treatment in the early part of August, 1901. The exposures were now made longer and at a shorter space from the tube. A dermatitis resulted, producing a superficial ulceration which is now healing rapidly.

"Case 2.—W. S. Male, aged fifty-seven, brought to the hospital October 29, 1900, with general paresis. One sister died of carcinoma and another of phthisis. Four years ago a small warty growth developed at the inner canthus of the left eye. This increased in size and soon ulcerated. A diagnosis of epithelioma was made and X-ray treatment begun March 8, 1901. At this time, as the photograph shows, the cancer involved the inner canthus of the left eye, and both lids to the extent of two-thirds of the palpebral tissue, and downward half the length of the nose. One of the left submaxillary glands was enlarged. The same technic was used as in the former case. After the first two exposures a lessening of secretion was noted, and after one month of treatment the lower portion of the growth had been replaced by apparently healthy skin. There was a gradual improvement despite the fact that the patient's general condition was growing progressively worse. On account of the difficulty in handling him the intervals between treatment had to be increased, but by July 17th the open surface was reduced to five centimetres, and this was granulating. The epithelioma had been replaced with what appeared to be healthy skin (except the margin of the open surface, which was thickened), and the indurated sub-maxillary gland had disappeared. I expected him to be well of the cancer in a week or two more, when, on July 17, 1901, he died of one of the episodes of his general paresis. The accompanying photograph shows his condition at that time. I wish to add that in this case it was impossible to shield the eye completely by the lead mask, but no bad results followed, not even a conjunctivitis. He had in all thirty-four exposures.

"Case 3.—D. H., male, aged seventy. One sister died of a growth about the knee which had existed five years; otherwise family history was negative. Four years ago a small papule developed on his lower right eyelid. This never disappeared, but as fast as a crust formed it would be torn off, leaving the growth each time a little larger than before. During the past year it has increased more rapidly in size. A diagnosis of epithelioma was made by three, the visiting dermatologist, a surgeon, and an ophthalmologist, and X-ray treatment was begun on April 26, 1901. At this time an elevated ulcerating growth occupied one-half of the central portion of the lower eyelid. (See Plates 176 and 177.)

"The technic of treatment was the same as before, except as to frequency. This was governed by the effects produced, and varied from one to nine days. In each instance the inflammatory reaction was allowed to disappear before repeating the exposure. The ulcer was completely healed by nineteen exposures covering two months. It has remained healthy during the two and a half months since treatment ceased. The ulcer has been replaced by healthy skin and a scar not more than one millimetre wide, which is freely movable. I use the word 'scar' here for want of a better term. It lacks, however, the characteristics of true scar-tissue, and is only a smooth white area in the skin. This covers a furrow which indicates the site of the previous destruction of the deeper tissues. The result obtained in this case is shown by the photograph taken two months after beginning the X-ray treatment. I have treated three other cases, all of which show improvement but are not yet well at this writing."

Dr. Hopkins recently reports:

"A change in the energizing force from the alternating current to the Static machine worked by an electric motor has certainly increased the effect of the *ray* on the diseased tissue. The time of exposure is a very important consideration in the treatment of this disease. At Hamburg, through the courtesy of Dr. Albers-Schönburg, I saw some skin cases under treatment. The time of exposure varied from ten to fifteen minutes; this is the general practice in Germany in treating skin diseases, particularly psoriasis, eczema, and lupus. I have reduced my exposures from thirty down to fifteen and five minutes, more often the latter period. My assistant and the parts of the patient which were not to be treated, I have found were well protected by several layers of lead-foil, glued to pasteboard or more flexible material, making an opening in this screen where the rays are desired to act. I have yet to see in my own hands, or those of my assistants, a case where any of the healthy tissues have been injured by treatment with an X-ray tube.

"The distance of the diseased portion of the body from the tube is also an important consideration. In my exposures I vary the distance from twelve to thirty inches; this is altogether governed by the effect desired, and is difficult to lay down by rule. Where daily exposures are to be made, the tube should be at a greater distance from the patient, than where exposures are to be made at longer intervals. The errors to be avoided are too long exposures, too short a distance between the tube and the patient, and improper apparatus."

"When this method by the X-ray is accepted as a general and safe treatment by the profession at large, fewer women will conceal the existence of a growth in the mammary gland than is now the case, as there is such an inborn dread in all of us of the use of the knife. The laity should be made to understand that there is another method of procedure in the treatment of malignant disease than by the use of the much-dreaded knife. I am personally as fond of the use of the knife as any surgeon, where it is best for the patient, so I can lay down the above rule with more propriety than men who are opposed to, or, not skilled in, surgery. The following case illustrates the benefit of the X-ray treatment in cases where there is no breaking down of tissue, and the mammary gland alone is involved, the axillary glands presenting no evidence of infection.

"No. 8.—Mrs. Aurille M., aged sixty-eight years, married, has had no children, always healthy. Her grandfather died of cancer. Several months ago slight pains called attention to her right breast, which on examination proved to be somewhat enlarged. It continued to increase in size until it was twice as large as the left. She consulted me on January 22, 1901, as she heard I was using 'electricity' in the treatment of cancer, and wanted my opinion. I was frank with her, and told her that the knife was the proven treatment, but that I was experimenting with the X-ray in such cases. She said she had come to me because she was not willing to subject herself to the knife, and wanted to try treatment by the *ray* even though it was in an experimental stage. The next day she took her first treatment. This was January 23d, and the exposure was five minutes; 24th, eight minutes; 25th, seven minutes; 26th, ten minutes; 28th, eight minutes; 29th, eight minutes; 30th, eight minutes; 31st, eight minutes. We could detect a change in the density and size of the gland by this time, and the breast felt more comfortable. February 1st, exposure eight minutes; 2d, fifteen minutes; 4th, ten minutes; 5th, eight minutes; 6th, seven minutes; 7th, seven minutes; 8th, seven minutes. She was improving so rapidly, and the breast was so much reduced in size that I suggested an intermission of treatment for a week or ten days. February 16th she presented herself again and the condition of the tumor continued satisfactory. Treatment was twelve minutes; 18th, twelve minutes; 19th, twelve minutes; 21st, ten minutes; 22d, ten minutes, and as she was going away for ten days on the 23d I exposed for eighteen minutes. March 2d, twelve minutes; 13th, eighteen minutes; 28th, not having had treatment for two weeks I gave a twenty-minute exposure. All the time the tumor had continued to decrease, and was nearly as small as the normal breast. As she was going to her country home for the summer on May 1st, I deemed it wise to give her a few more treatments and try to bring the right breast absolutely down to the size of the left. With this end in view I gave her the following treatments: March 30th, eight minutes; April 1st, ten minutes; 5th, ten minutes; 8th, ten minutes; 10th, eight minutes; 12th, eight minutes; 16th, eight minutes; 18th, eight minutes. As the breast was practically reduced to the size of the healthy one and all disagreeable sensations had ceased, I saw no further occasion for treatment, but cautioned her to report to me on the least increase of size, or return of pain in the breast. This she said she would do.

"In all these cases the first effect observed is a decrease in the density of the tumor. This change in consistency governs very largely the time of exposure, for, should we carry this process too far, necrosis of tissue would occur. This is a condition which we must studiously try to avoid. Experience has demonstrated that it is not necessary to carry the treatment to this extent even in advanced cases, as they will heal under less exposure than is necessary to produce complete destruction of the diseased area. In cases that have broken down and ulcerated, the effect of the X-ray treatment shows itself very promptly. *In these cases the exposure is not of necessity more prolonged than in milder cases, as one would naturally expect.*

"I have had a very interesting case where I have used a combination of the X-ray and Finsen light. This case was a patient who had had the left breast amputated and the entire axillary plexus of glands removed, as they were involved in the disease. The extensive wound healed promptly, but the cicatrix subsequently broke down and began to ulcerate. The necrosis was an inch deep. Yet under the combined influence of X-rays and violet and ultra-violet rays of the Finsen apparatus, the cicatrix has completely healed. A fungating cancer of the breast was recently brought to me for treatment, the hardened right breast was at least seven and one-half inches in diameter. The discharge was offensive; but after a few treatments with the X-ray the character of the discharge changed and the odor disappeared; the fungating mass has retracted; the whole breast is softening, and the patient is relieved of all the pain and discomfort she was suffering. She says, 'if the treatment does nothing more than make me as comfortable as I am now it is quite worth while.' Though final conclusions must be deferred I am sure that we can be perfectly justified in advising our patients to use this form of treatment." (September 7, 1901.)

"Mr. S.—Cancer of epithelial variety on right side of face. The cancer had eaten out the right side of the nose and had almost reached the orbit. The patient suffered severely; discharge and odor very bad; diagnosis confirmed by several consultants and a prognosis of three months limit of life was made. Treatment was begun a little over two years ago. A low tube and an improperly fitting mask caused the patient to be burned unnecessarily, but it was among my first cases. However, after the effects of the burn disappeared the face healed rapidly. Soon after the first treatment the odor, pain, and discharge were gone. The site has been perfectly healthy since treatment was stopped nearly two years ago and appears likely to remain so." (Blackmarr, August, 1901.) See Plate 179.

Andrew Clarke has reported (*British Medical Journal*) a case of carcinoma of the breast too far advanced for operation, in which the use of X-rays for nine weeks produced a marked improvement. Exposures were made for fifteen minutes at a time, five days each week. The ulceration and discharge greatly diminished, the axillary glands became smaller, and general improvement followed. In several papers during the early part of 1901 Williams expressed the opinion that we have in the radiation from a Crookes tube a valuable therapeutic agent in epithelioma, and that the beneficent action of the X-rays can be brought about without causing a burn. Without causing pain and without any caustic action the application of the X-rays is followed by a cessation of foul and almost unbearable odors, a lessening of the discharge, and diminution of the size of the growth. Even if its curative action is found to be limited to superficial growths, it may be of use as a means of relieving the painful features of other forms of the disease. In one special case reported, five-minute exposures were made nearly every day for some weeks. Experience has suggested that so long a period of treatment is unnecessary. The diagnosis of epidermoid cancer was confirmed by histological examination and a picture of the case showed the ulcerated and indurated margin of the lower lip, the induration extending some little distance into the tissue. A lymphatic gland under the lower jaw on the right side was enlarged. At the close of treatment the induration had disappeared; the lip where the growth had been was without a scar and perfectly smooth and soft; the enlargement of the lymphatic gland had disappeared; and, except a little increase in width on the affected side, there was nothing abnormal in its appearance. Later, this increase in width diminished so that the cosmetic effect was perfectly satisfactory.

Dr. J. H. Sequeira reports a series of twelve cases of rodent ulcer which he has treated by the X-rays. The current used was one of from three to four amperes; the coil was a ten-inch spark, and the tube was placed about six inches from the ulcer, the adjacent parts of the skin being protected by a layer of lead-foil. The treatment lasted ten minutes and was repeated daily. So far the author has only treated cases deemed to be unsuitable for operation. Of his twelve cases, eight are still under treatment and four are under observation, the ulcers having healed. In no case has there been a disappointing result, and all the cases still under treatment are in various stages of healing.

Stembeck reported, in April, 1901, a case of rodent ulcer on the tip of the nose of a woman, aged sixty-seven, treated by X-rays. They were applied for ten minutes daily, with the tube at four inches.

Reaction occurred after four sittings, and on the tenth pus appeared. After thirty-five treatments the ulcer was more healthy, and the epidermis began to grow in from the edges. After a short interval the sittings were increased to fifteen minutes, and a second reaction took place followed by improvement. The epidermis grew over the ulcer, the edges flattened down, and in a month a smooth cicatrix was left differing little from the facial epidermis, and surrounded by a slightly raised border. The ulcer had been present nine years. In other chapters of this section we have several references to the treatment of rodent ulcer, and shall make no attempt to collect additional cases here. Many of the large European hospitals which are doing active therapeutic work with X-rays report the daily treatment of a dozen or more cases of Rodent ulcer in the X-ray clinic. Results are praised very highly.

In July, 1901, the Electrical and Radiographic Department of the London Hospital was treating daily by X-rays some three or four dozen cases of skin disease, of which about half were rodent ulcer and the other half lupus. In the Finsen Light Department of the same hospital, the number of cases treated each day was about 100, chiefly lupus. The opportunities for comparison on such a scale should determine the relative merits of each method. At the date reported the discharges from X-ray tubes appeared to be more efficient than concentrated light in the treatment of rodent ulcer. At the beginning of 1902 we find a great increase in hospital work of this nature in many quarters of the globe. We still, however, await results in cases of internal cancer.

Method of X-Ray Treatment.—The technic in all these ulcerating lesions is practically the same as explicitly taught in our study of lupus. Vary the details of dosage according to the observed effects, but follow the same principles in all. The greatest possible benefit will be given most patients by combining the use of Static electricity with X-ray exposures. Employ this current alternately, both for local assistance and especially for its great capacity to improve the general nutrition and well-being of the patient. Correct methods of technic have been taught by the author in his writings on this form of apparatus. Those who know Static electricity only in its common routine applications will be greatly pleased to learn how to enormously increase its efficiency in these cases. Many cases of sarcoma have been tentatively treated with X-rays, and many are encouraged by the results. In all classes of cases treated by electrical radiations of any kind the best results have been gained when the lesion has presented an exposed surface. Affected glands under sound skin have not yielded as good results. A few cases of internal cancers have been treated and much benefit has been claimed by some. At this writing we can only leave the subject to investigation and further research. See Plates 174, 175, 176, 178, 179, and 180 for pictorial methods. Also note remarks on page 73 regarding lead masks for malignant disease. Study carefully our entire section on X-ray therapy and apply the principles to any given case. Our pictures of technique, photographed especially for this work, show clearly how to proceed in a variety of cases.

CHAPTER XLII

TUBERCULOSIS AND X-RAY THERAPY

Laboratory and Clinical Results. Technic for X-Ray Treatment.

If the X-ray was demonstrably capable of carrying with its penetrating capacity an electro-chemical action destructive of microbes into the tissues, the treatment of consumption would be solved. Some have thought that the problem was nearly as simple as this, and have accepted as final the early conclusions of Rieder. It is the author's personal opinion that the action (if any) of X-rays upon tuberculous internal tissues ought to have been proved long ere this, but proof is still wanted. Owing to the fact that X-rays penetrate so freely the human body it would apparently be of immense therapeutic importance if it could be proved that they possessed the properties of destroying germs or retarding their growth or of so increasing tissue resistance as to aid nature in overpowering bacilli. Theoretically, it ought to be very easy to prove this one way or the other. After four years of active research and a large therapeutic experience, it ought to be settled whether or not the X-ray will carry through the tissues the one decisive action for which the profession waits.

Practically the question appears to be very difficult to settle, and is as open in 1902 as it was in 1896. When a culture in any tube is exposed by an investigator it may be exposed at a greater or less distance, for a longer or shorter time, to a discharge of a higher or lower intensity, and the media may differ; hence, discordant statements and discrepancies appear which bewilder us with the uncertainties of scientific bacteriology. Some authors kill bacilli with X-rays, some make them grow more slowly, some stimulate them to increase activity and growth, and some grow them gradually to death. When cultures are X-rayed they may be influenced by:

1. The X-rays proper.
2. The cathode rays.
3. Electrical actions.
4. Ozone generated by the electrical discharge.
5. Increase of temperature.

6. Chemical or other changes in the media.
7. Light from the tube, or other source.

These would seem to be controllable factors. Light can be excluded by inclosing the tubes in black paper the same as a photographic plate. The culture can be replaced sufficiently distant from the anode to be beyond the reach of cathode rays and the electrostatic field. Ozone can be eliminated, and it would certainly seem that long ere this the question should have been decided. We will not confuse the reader by citing at length any of the more important but conflicting contributions on this subject. However positive the evidence may be in any single report we are obliged to regret that proof of direct germicidal action is not conclusive. Much of the applause given X-rays in tuberculosis and parasitic skin diseases has been based upon the supposition that X-ray therapy was, in fact, the long-sought antiseptic therapy, and even if it is not possible to demonstrate this with culture tubes and biological incubators, it ought to be possible to do it in the simplest manner upon the living patient. If X-rays carry with them through the tissues any destructive influence on bacilli then we should be able to place a tuberculous patient in the path of the rays and in the course of time find out from the sputum whether or not there was any destruction of the bacilli. Ten competent clinicians experimenting each on ten different patients for a year should be able to settle the matter regardless of other methods. Whether or not the benefits derived from X-ray treatment in hundreds of reported cases have any relation to germ-destroying properties in the rays, it is certain that if the rays actually and readily kill tubercle bacilli *the fact ought to be susceptible of proof.* Clinical proof of the possession of this property would be one of the most gratifying contributions which the opening of the twentieth century could offer the medical profession.

Space will not permit us to repeat here the reports on both sides of the controversy respecting the ability of X-rays to destroy germs. At least six eminent authorities could be quoted on each side. The effect produced on cultures of micro-organisms and of tubercle bacilli by exposure to X-rays has received world-wide study and is of the greatest interest, but it is still a clinical problem. We cannot place too much reliance on the behavior of guinea-pigs under X-rays, nor on the results with patients who at the same time *have other approved treatment.* Yet the impression is growing that X-ray therapy has a useful field in pulmonary tuberculosis. Personally the author believes that the rays must be demonstrated to possess an actual bactericidal power before they can be accepted as superior to other

PLATE 181.—Raying a Case of Pulmonary Tuberculosis. The camera has made the tube appear too high. Level the axis of the rays directly upon the diseased area. The plate shows the operator inspecting the progress of the disease with the fluoroscope. In a systematic course of treatment expose the back of the patient at one sitting and the front at the next sitting, and alternate at successive séances. A chair with an open back to support the patient should be used.

Photographed exclusively for this work by Dr. Jicinsky, who reports: "J. H., age twenty-six, fluoroscope shows slight haziness over both apices; anode focussed directly upon diseased area; tube twelve inches from surface of body; exposure ten minutes at first four times a week, then three times a week. Used improved German tube and ten-plate Static machine. After two months' treatment patient had gained ten pounds. Night sweats ceased; coughed no more. Regulated personal hygiene, but gave no medication. Feels improved and haziness nearly gone."

Plate 182.—Case treated by Dr. F. H. Blackmarr, Chicago, and method photographed especially for this book.

"Mrs. V., history of tuberculosis. Operation upon cervical glands. Patient well for short period after operation. Remaining glands enlarged to the size of walnuts. X-ray exposure, time varying from ten to fifteen minutes daily, until marked 'sunburn' developed. After first week no night sweats, appetite improved, patient feeling better. She has been well now for nearly eighteen months."

PLATE 183.—Rabbit being X-rayed for tuberculosis test after inoculation with bacilli. Photographed by Dr. Jicinsky.

PLATE 184.—Osteo-sarcoma of the Os Calcis. (Rebman, Ltd.)

forms of efficient electricity. If the rays are merely an indirect nutritional agent without specific influence upon the bacilli the author considers that we have more flexible, various, and effective therapeutic resources in galvanic, static, and high-frequency electric currents than in the attenuated discharge which is associated with the phenomena of X-rays. But this opinion will not be maintained if evidence to the contrary is established. This chapter will now close with a recent report from a physician whose results should induce many to investigate the subject.

"My attention was first called to the possibilities of its use in tuberculosis three years ago by the relief that was found by the patient on making a radiograph of a tubercular knee-joint. I made an exposure of ten minutes with the inefficient apparatus then in use, and got a good negative, but the surgeon wished a different view and I repeated the exposure four days later. The patient claimed that he had the first relief from pain he had experienced for many months. Two weeks afterward he came back and begged for another exposure, and after a consultation it was refused. The subsequent history will be found later on. This case set me to experimenting on a few cases of tubercular joints that came to my clinic, and I found that one injection of iodoform emulsion and subsequent treatment with the ray usually was followed by immediate improvement and a subsequent recovery. It might be mentioned in passing that iodoform fluoresces beautifully under the ray. (See Plates 161, 162, and 163.)

"A bad case of pulmonary tuberculosis presented itself at this time. He had been under treatment for a number of months at the clinic, and was getting so weak that it was only with the greatest difficulty that he could get to the hospital. And he was very anxious to have a radiograph taken of his lung, and to humor him I took it; and he came back and asked me to use it again, as he had felt better than he had for some time. I had him come twice per week and take treatments, not expecting it would do him any good. No special change was noted until he had taken six treatments, when his cough left him and his temperature became normal. When he took his tenth treatment he reported that he had gained twelve pounds in weight and had been working for a week; the subsequent history will be found in the report of the case. I will report briefly a few of the cases that I have treated with the ray. They are fairly representative of the whole number of thirteen cases of pulmonary and five cases of joint tuberculosis that I have submitted to the ray treatment. It is of interest to say that they are all enjoying good health at present and pursuing their various vocations as if they had not suffered from the dread disease. As yet no relapses have been noted, but are being carefully looked for and will be promptly treated if noted. (See Plates 181 and 182.)

"Case 1.—John M., aged twenty-six, single. Met with an accident July 10, 1896, by falling off a wagon, and as he went to work the next day he apparently did not meet with an injury. August 20, 1896, he found that his knee-joint seemed to be weak and he had difficulty in using it, and it grew steadily worse until he could not bear his weight upon it. The joint became swollen and painful on pressure, and a marked atrophy was noticed of the muscles. He consulted an eminent surgeon and a diagnosis of tuberculosis was made and he was advised to have iodoform injected into the joint. He submitted to eight injections without stopping the process, and then had the leg put up in plaster for four months; and when it was removed it was so bad that an amputation or an excision was advised, and he was sent to me to determine by means of a radiograph which would be advisable.

"Two radiographs were taken of the joint four days apart, and the exposure was ten minutes each time with the apparatus then in use; and the patient claimed so much relief that he begged for further exposures, and after a consultation with the surgeon it was refused. It is interesting to know that the patient did not receive any more treatment of any kind, but recovered the use of his joint in about four months and at the same time his health and is working every day driving a team.

"Case 2.—William F., aged twenty-eight, married, pulmonary tuberculosis. Had been under treatment for four months and was steadily growing worse. Temperature 101.5, severe cough, sputa contained tubercle bacilli and streptococci; he had night sweats and a profuse diarrhœa. Treatment was given at his request and with no hope of success. Treatment was given twice a week with a very high-vacuum tube. No special improvement was noticed for four weeks, when he began to slowly improve and gain in weight, slept better, sputa lessened in amount and became more liquid and contained less bacilli, and the fever gradually left him, until at the end of ten weeks he was discharged; and, although a few bacilli are found occasionally, as far as can be told he is in good health and working every day.

"Case 3.—Margarette L., aged twenty-four, widow, one child, poorly nourished. Developed pulmonary tuberculosis five months previous to consulting me, when I was called to see her for a severe hemorrhage from the lung. Both lungs were involved and the bacilli tuberculosis were found in great quantities. She was so feeble and exhausted that it did not seem that there was even a remote possibility that she could recover. It took two weeks of careful nursing to bring back strength to allow her to ride to my office for treatments. And the first two calls were made in a cab. She subsequently came on the street cars, as she improved. After six treatments I put her on tonics, when the improvement was rapid. She increased in weight from ninety-three pounds to 118, the most she ever weighed. She has resumed her place as a waitress in a restaurant and works twelve

PLATE 185.—Multiple Osteoma. The electrotype gives a very faint idea of the diagnostic value of the negative. (Rebman, Ltd.)

PLATE 186.—Osteo-sarcoma of the Ulna. (Rebman, Ltd.)

Plate 187.—Bony Ankylosis of Knee from injury eight years previous and having been twice for long periods fixed in plaster splints. (Rebman, Ltd.)

Plate 188.—Ankylosis of Elbow. (Rebman, Ltd.)

hours per day and has been doing it for months. I have been able to find tubercle bacilli only twice in the last year. The above cases are a fair sample of the rest that I have treated." (BURDICK, July, 1901.)

Technic for X-Ray Treatment of Pulmonary Tuberculosis.—Query from physician: "I have a tuberculous patient whom I wish to expose to X-ray therapy. There is some consolidation of the upper left apex and also dulness over spine in lower region. Patient has only slight temperature, slightly increased pulse, no night sweats or coughs. Appetite normal, bowels regular; in a word, incipient tuberculosis. How near ought the tube to be placed to the chest (front or rear?), what length of exposure allowed, and how often?"

Answer. Strip the thorax, either entirely or down to close-fitting underclothing. Seat the patient on a revolving stool facing a tube with its wall eight inches from the tissues, and with its focus levelled at right angles to the third rib. Use a good tube giving brilliant radiance. If you have the author's gauge to test the radiance with use at least X_6. Between patient and tube fix a grounded metal screen (say, fifteen inches square), with its lower border just below the slightly raised chin to cut off action from the face, and especially from the hair. Begin the exposure with the axis of rays focussed on the apex of one side. Direct the patient to gradually turn the body so that during a séance of twenty minutes, each affected area will slowly pass into the most active path of radiation, to wit, in the central axis of the rays from the anode as taught by our Divergence Chart. A little bending and posturing of the body as it is turned from one side to the other will accomplish this. In the second treatment seat the patient with back to tube and expose the posterior tissues. Make twenty-minute exposures in this manner three times a week. While the rays penetrate through the body yet the maximum effect is nearest the tube, hence reverse the patient in alternate séances. See Plate 181.

Use all other indicated measures. Especially use Static electricity in alternation with the X-rays by methods taught in our writings on this current. From very large clinical experience and from cumulative evidence from many observers we are obliged to say that a tuberculous patient in any stage of the disease is not given the benefit of scientific therapy if static or High-Frequency electricity is omitted from the treatment. It is the most decisive and important remedy in the entire chain of our resources with which to combat this disease. The diverse indications for it call for many variations in its application, especially with reference to the digestive tract, the general muscular state, symptomatic disturbances, the cough, expectoration, respiratory capacity, pleuritic pains, etc.

With this short chapter we shall now close our section on X-ray therapy. Resisting many temptations to insert interesting matter and to enlarge upon controverted points, we have rigidly adhered to our plan of keeping the text of this work in the strict line of practical instruction. Those who have not reviewed the diffuse and undigested literature of our subject during the past five years can scarcely appreciate the great service rendered the reader of a single compact volume by efficient and reliable condensation. This service the author has performed to the best of his ability, and it is believed that the result is a course of instruction which can be safely followed by beginners and confidently applied to their patients. After defining the essential terms in X-ray nomenclature we will next take up the related subject of photo-therapy.

CHAPTER XLIII

X-RAY NOMENCLATURE

Definitions of Common Terms Employed.

Readers of scattered X-ray literature, covering contributions by American writers and translations from the German and French, have observed a lack of uniformity in the use of X-ray terms. Some authors also attach different meanings to words already employed in a different sense by others. Some make the word "radioscopy" include the use of both the fluoroscope and photographic plates. Some use "radioscopic" in a sense that others restrict to "fluoroscopic." With one a "skiameter" is a device to place against the patient as a comparative measure of the density of shadows in fluoroscopic examinations of the thorax. With others it is a series of layers of aluminum or other metal, either punched with holes or numbered, and designed to indicate the working efficiency of a tube. Others still call a similar device a "photometer" or "radiometer."

It needs no argument to show that a standard nomenclature is wanted. And particularly a root-word is needed that will indicate by various terminations the different branches of X-ray work without confusion. Some of the new words already offered for this purpose, and deemed original by those suggesting them, appear in the dictionary with other meanings, and confusion has resulted. It is no part of our purpose to originate terms or to change the meaning of any already in use, but for the instruction of the beginner we will here note down a brief list of the more important words which have become more or less established in X-ray literature. It will be informing to first see what dictionaries already say about some of the terms employed. We find the following old definitions:

Fluorescence.—The property of becoming self-luminous under the direct action of light rays. This word was coined by Stokes in 1852.

Phosphorescence.—Shining with a faint light; luminous without sensible heat or combustion; a species of fluorescence.

Radial.—Of or pertaining to a ray or a radius; shooting out from a centre; having the character or appearance of a ray or a radius. A radiating or radial part; a ray.

Radiometer.—1. An old instrument for measuring angles; the cross-staff. 2. An instrument which serves to transform radiant energy into mechanical work. Crookes Radiometer consists of four crossed arms of very fine glass, supported in the centre by a needle-point, and having at the extreme ends thin vertical disks or squares of pith, blackened on one side. When placed in a glass vessel nearly exhausted of air and exposed to rays of light or heat the blackened surfaces absorb the radiant energy and become heated, etc., and thus various experiments are performed which illustrate the mechanical effects of rapidly moving molecules of a gas.

Radiograph.—An instrument for measuring and recording the intensity of solar radiation. Improved by Winstanly in 1881. *Ray*-writing.

Sciagraph.—*Shade*-writing. The geometrical representation of a vertical section of a building, showing its interior structure or arrangement.

Sciagraphy.—Painting in light and shadow; the act or art of delineating shadows correctly in drawing. A geometrical profile of a section of a building to exhibit its interior structure.

Sciagrapher.—One skilled in sciagraphy. A student of the gradations of light and shade.

Sciametry.—The doctrine of eclipses and the theory of the connection of their magnitudes with the semidiameters and parallaxes to the sun and moon.

Scioscopy.—Same as Skiascopy.

Ski.—A long narrow strip of wood made into a snow-shoe.

Skiagraphy.—Same as sciagraphy.

Skiascopy.—Shadow-view. Shadow test. A method of estimating the refraction of an eye by throwing into it light from an opthalmoscopic mirror and observing the movement which the retinal illumination makes on slightly rotating the mirror. Also called *retinoscopy*, etc.

The above are the main words defined in the Century Dictionary prior to the X-ray era. Those who cannot endure "hybrid" words such as combine the Latin with the Greek, for instance, *radiograph*—will find this word long established in *scientific* circles. But as the dictionary shows thousands of common words defined under *several* headings it need not trouble us that words adopted into X-ray usage have long had other applications. Those now permanently incorporated into this branch of practice may be explained as follows:

Cryptoscope.—An early term for the Fluoroscope. Now practically obsolete in this country, though still employed occasionally in Europe.

Film.—The sensitive surface of the photographic glass plate or the separate photographic film without the glass backing. Special films are made for X-ray work. The words " plate " and " negative " are currently used as convertible terms, but *film* specifically refers to the sensitized surface acted upon by the rays.

Fluoroscope.—The complete pyramidal box and fluorescing screen used for visual examinations with X-rays. Formerly called cryptoscope in its first shape.

Fluorometer.—A special localizing apparatus. A coined word introduced by the makers of the apparatus.

Fluoroscopic.—Examinations with the fluoroscope.

Fluoroscopy.—The science and art of using the fluoroscope in X-ray inspections.

Radiogram.—An X-ray picture; a term coined for this use but now nearly displaced by radiograph, which is in most common usage.

Radiograph.—In X-ray nomenclature the negative and the print from it are both called indifferently radiographs and skiagraphs. The intent is the same.

Radiometer.—Some applied this word to a measure of X-ray penetration, but it is little used, and was at once objected to because of its previous application.

Radiology.—Some writers have thus indicated the entire study of X-ray phenomena. It is little used in America.

Radioscopy.—Some have used this word to signify fluoroscopy. Others have used it to denote both " fluoroscopy " and " radiography." Foreign writers use it more than American authors.

Radiotherapy.—Some use this word instead of X-ray therapy. When met with in print it signifies the therapeutic application of the discharges from an X-ray tube.

Skiagram.—Has the same meaning as the word " Radiogram." Is very little used.

Skiagraph.—Same as " radiograph," and preferred by some. One is as correct as the other. Both are used interchangeably in this book.

Skiascopic.—Same as fluoroscopic.

Skiascopy.—Same as radioscopy. These words are little used.

Skiameter.—A device for comparing shadow-values. See description in another section of this work. A shadow-measure.

Screen.—Generally, the fluorescing screen used for visual X-ray examinations. A specially prepared "screen" to place in contact with the film in making an X-ray picture is called an "intensifying," or "photographic" screen, and is fully described in another section of this work. A "protecting screen" is a thin sheet of metal used to keep electrical discharges from the patient.

These are the principal words now peculiar to X-ray nomenclature. Few and simple as they are some confusion has already occurred, especially in translations from foreign sources, from the lack of a common basis of application. Beginners, however, will soon learn to comprehend an author's meaning by the context and thus avoid doubtful interpretations. When meeting "Staniol" for the first time with reference to protecting a patient from an X-ray dermatitis know that the author who employs it simply means tin-foil. A "mask" is literally an ordinary mask of starched muslin, such as children call a "false face." When coated with tin-foil it becomes a part of certain X-ray technique. The word "tube" always means a Crookes tube and the source of X-radiation, unless otherwise stated in the text. The "focus" is the point on the anode from which the rays start. The Anode is the diagonal electrode within the tube, and is always to be connected with the positive pole of the electrical apparatus. The Anode is often called the anti-cathode. The Cathode is the round electrode in the tube, and is connected with the negative pole of the current. A "spreader" is a wooden or vulcanite rod on the tube-holder designed to keep the cords connecting the tube with the current widely apart. Many minor words define themselves by the context. As skiagraph and radiograph mean the same thing it is customary to use the one which fits best in a given sentence, and the reader need not infer that one is superior to the other.

Studies in Photo-Therapy

"*To-day scarcely any one doubts the energetic therapeutic action of blue electric light.*"—(MININ.)

CHAPTER XLIV

LOCAL PHOTO-THERAPY

A Rudimentary Explanation. Finsen's Work. Photo-Chemical Therapy. Experimental Data. Technic of Finsen's Lupus Method. Details of Treatment in Full. New Lupus Lamp. Method of Treatment with the Lortet-Genoud Lupus Lamp. The Foveau-Trouvé Lamp. Progress in Photo-Therapy Lamps. Sun Cases.

The scientific and advancing photo-therapy of the twentieth century has begun with two sharply distinctive lines of research and development, one seeking strictly local and photo-chemical actions and the other mixing the chemical with the luminous and red rays and dosing their proportions to meet local and general indications of an entirely different character. Three general terms have arisen to express the three branches of work now done with electric-light apparatus of different kinds; Finsen's therapy, Light treatment, and Radiant Heat Baths. The photo-therapy allied to Finsen's work deals mainly with very small local applications of *cold chemical rays* of light to lupus and similar small lesions which are adapted to its minute contact-device. "Light treatment" is the larger and more general application of the chemical or mixed rays, or even whole-light from certain lamps, for tonic and nutritional purposes as an intensified sun-bath, especially in the treatment of pulmonary tuberculosis, and general skin diseases amenable to "light" action. Radiant Heat employs whole light with special reference to the production of "warm sunshine," and occupies the therapeutic field of super-heated dry air with important advantages which will appear in our course of study.

Photo-therapy is dependent on mechanical variations in the construction of sources of light which will permit the selection of such rays out of the spectrum as will have the needed physiological actions, and as great advances are promising in this way we commend the study of this section with confidence that before this book is old we shall see practical apparatus conforming to the private practitioner's needs in very general use in the profession.

A Rudimentary Explanation.—Common familiarity with electric-light for illuminating purposes has *un*-prepared the physician to consider it a *therapeutic* agent. If *light* really possesses the properties that are claimed for it how is it that millions of people work for hours daily near arc and incandescent lamps without any of the effects now brought to our attention? Perhaps many readers have made this fact an argument to reject as a surprising and incomprehensible *fad* the whole romance of photo-therapy, but the explanation is very simple.

Lamps for *illuminating* uses are made with but moderate candle-power and with glass globes which let the luminous rays pass more or less freely through them, but which screen off part of the heat radiation and all of the higher chemical rays. Commercial lights therefore are made to yield *luminous* effects for illuminating purposes, with special economy directed to this one end. The practical purpose of the *Therapeutic Light* is radically different. It is to furnish the physician with an artificial sun which can be commanded at will, and focused, filtered, modified, and directed to set up certain physiologic actions upon a definite local area, or to otherwise influence the general system. Between the neutral actions of luminiferous rays from the commercial electric-light, in the general illumination of which a person may pass hours at a time with no more than the imperceptible tonic influence of light *vs.* the dark, and the scientific therapeutics of concentrated rays filtered out of the spectrum for specific chemical or radiant-heat action, and focussed upon a definite area of prepared tissue with a *definitely dosed intensity* of from a single thousand to 60,000 candle-power, there is a difference similar to that between washing the hands in a basin of neutral water and the full resources of modern hydro-therapy. Every physician can understand what this means.

No doubt the developed apparatus must be seen at work to be appreciated, for practitioners glancing through current journal articles often fail to grasp the merits of what does not come before their own eyes for personal examination and test; but the Instruction Plates in this section will lessen the difficulties of recognizing the basis of photo-therapy. Neither one kind of light, nor one form of apparatus, nor one dosage, nor one technic, is the whole of photo-therapy. Far from it. To secure the many grades of effects we need several mechanical devices to alter the latent energy of light into an agent of the materia medica. It must be prescribed to meet indications. These may call for a local or general dose, a dose at close contact or at distances up to four feet, a dose restricted to either chemical rays or radiant-heat rays, or both in modified combination; or whole-light with all its complex mixture of properties may be needed for the case. From a single sixteen candle-power lamp to a group of fifty; from special Lortet, Bangs, Nernst, or Dowsing and other lamps, and from small arcs up to great craters with carbons an inch and a quarter in diameter and giving the light of 60,000 candles, we have a range of dosage and action that compares in extent with the scope of other physical therapeutics. The material of an incandescent filament can greatly alter the composition of the light-rays proceeding from it, and this fact is utilized in the construction of therapeutic lamps.

Some may ask why the *arc*-light is required for intense local photochemical effects. Has the incandescent light no chemical rays? Yes, but the ordinary incandescent lamp has a very low candle-power and is inclosed also in glass, which is a great barrier to ultra-violet rays and to most of the visible chemical rays. A sixteen candle-power lamp might give a dosage of actinic rays comparable with one-tenth of a milliampere in galvanic dosage and too small for work. A thirty-two candle-power incandescent lamp generates considerable heat. A fifty candle-power lamp gets very hot. A 100 candle-power incandescent lamp is seldom seen. The generation of heat makes a large incandescent lamps impracticable. But for chemical effects on lupus a light of 100 candle-power would be like a drink of a drop of water to a man craving a pint. To get enough chemical rays for active therapeutic effects of certain kinds a total light of 30,000 to 40,000 candle-power has been required, and the only mechanical device that can as yet furnish this without dangerous heat is the arc.

In the crater of a great arc-light the heat is estimated at over 6,000 degrees F., but it does not radiate far out into the air. It can be screened from the patient and cooled, and high intensities are thus possible. For some other needs in phototherapy the incandescent light is more valuable than the arc, but each has its field and meets different indications. The fact that the incandescent light cannot be used without a glass globe while an arc can, is another reason why the *chemical* rays of the latter have been more accessible to the physician.

Beginning then with the understanding that photo-therapy selects and applies the three main energies of composite light under a variety of conditions which are regulated by medical and surgical judgment, and that the results are only secured through the aid of the directing devices of photo-mechanics, we may intelligently take up the study of details. Beginning in our next paragraph with the pioneer apparatus first in the field and employing fifty to seventy amperes of current, the reader will note as we proceed through this section the gradual simplification of lamps and the rapid lessening of the quantity of current required. It is along these lines of practical development that photo-therapy will find its way into common use.

Finsen's Institute Work.—To American practitioners, who have but little heeded the development of photo-therapy or suspect its growth, the facts of Finsen's work will come like a revelation. Both to instruct the reader and to record its status in an historic year we shall cite from Stelwagon's visit to the Copenhagen Institute about July, 1900:

"The Institute consists of several one-story buildings; laboratory, reception-room, room for treatment of mucous membranes, two for the light treatment itself, and tables and stands for sunlight treatment outdoors. The sun is used in summer and in clear weather. The electric equipment is five large arc-lights of sixty to eighty amperes, each having four condenser-tubes dividing the light to treat four patients at once. About each arc-light are four tables with a patient on each, the face outside the lesion covered from the rays, a nurse with dark glasses pressing the 'compressor' on the spot marked by the physician for treatment—and sets of twenty patients rotating every hour and a quarter through the day. An hour is allowed for the exposure and fifteen minutes for changing the patients, adjusting the rays, etc. Nurses, assistants, and patients agree that the arc-light is better than the sun. It is stronger in action, and, therefore, the immediate reaction is sharper than by the sunlight treatment. (Plates 189, 190, 191, 192, and 193.)

"The number of lupus cases here for treatment seems legion. The tables are occupied *from half-past seven in the morning till nine in the evening*, except the noon rest of two hours allowed attendants. In 1897 there were seven patients. Now, the clientele has grown beyond management, and *more than 100 are on the waiting list!* They come from all parts of the world. Professor Finsen, Drs. Bie, Bangs, Larsen, Balee, Sunding-Smith, and Forcheimer, and all associated with the Institute, are even more enthusiastic to-day than in the first year of the work. Their earnestness must impress every visitor, as it did me, and very positively indicates that it is not novelty that is attracting patients but actual work. The patients themselves seem enthusiastic and come daily with unvarying regularity. The interest of the nation and city has been aroused. The government has contributed 225,000 kronen. The treatment seems successful. Recurrences seem rare and easily managed. In slight cases a few months' treatment will suffice, but in extensive cases more than a year is needed. I saw and conversed with a few patients who had

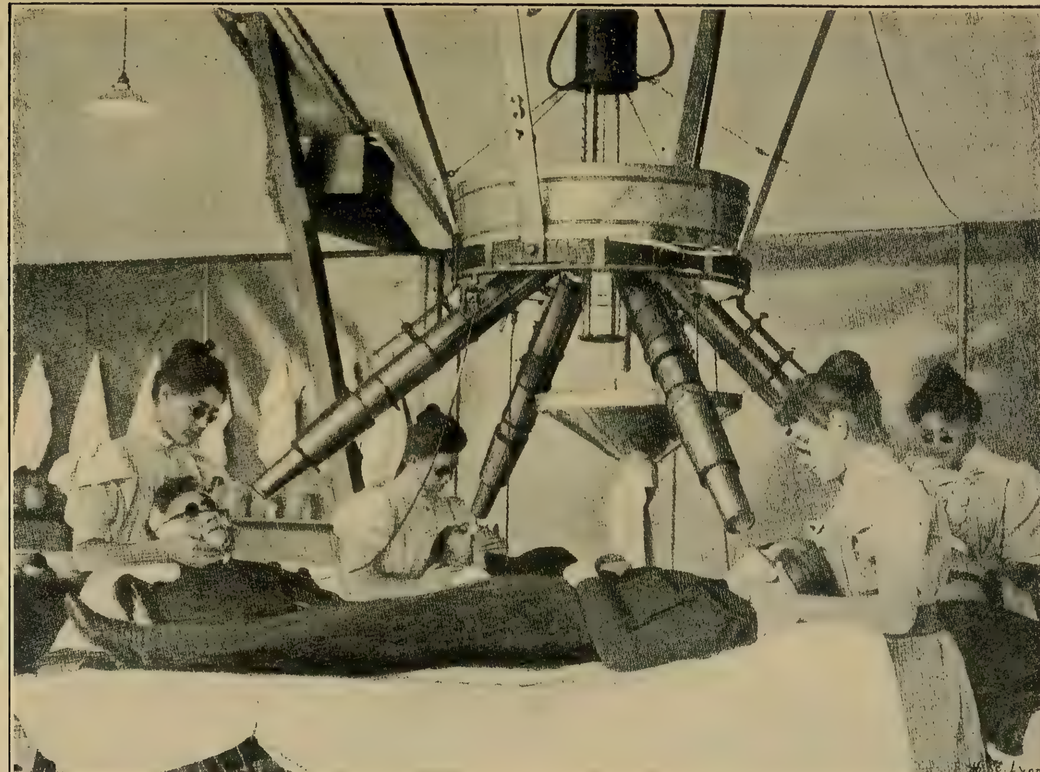


PLATE 189.—Finsen's pioneer arc-light "tube" apparatus treating four patients] an hour. Its interest here is chiefly historical. These pictures were sent author by Dr. Finsen.

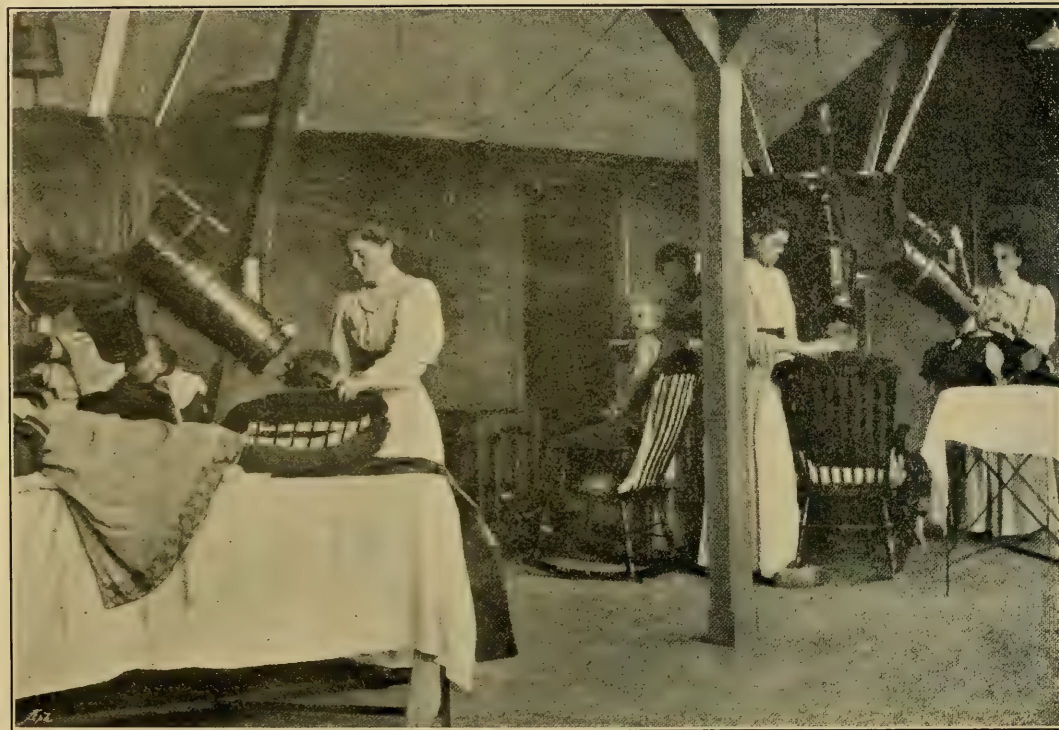


PLATE 190.—Scene in one of Finsen's treatment rooms.

PLATE 191.—Sunlight treatment in Finsen's Institute. A scene out-doors in summer.

PLATE 192.—Another scene showing sunlight treatment of lupus cases.

had a daily sitting for more than a year, but even these were satisfied with their progress."

A considerable number of physicians from all civilized countries have visited and reported on the work of the Finsen Light Institute at Copenhagen. Dr. Stephen Mackensie in England noted as follows:

"During the four years the treatment has been carried on the apparatus has undergone great development and improvement, with correspondingly increased results. I was greatly impressed with the equipment, organization, and management. The impression I formed of the light treatment of lupus was very favorable. In the cured cases the scars were supple and smooth, without contraction, and less unsightly than by other methods of treatment. Where the lupus nodules were superficial, the results were uniformly good. Where the nodules were deeply situated, they were less satisfactory, owing to the difficulty to the penetration of the light, and the treatment had to extend over a greater length of time. Many of the cases were of extreme severity, chronicity and extent, affording a very unfavorable prospect of success by any treatment. Some would not have been undertaken had they not been sent by medical men. In most of the very severe cases the mucous membranes of the lips, gums, inside of cheeks, tongue, and nostrils were implicated, and in not a few the palate and larynx were affected. It appeared to me that the mucous membranes were distinctly more frequently involved in the Scandinavian cases than in those seen in this country, and quite a large proportion had perforations of the septum nasi. I gathered from the physician in charge of the clinical department that the mucous membranes are affected in about seventy-five per cent. of the cases. The general run of cases seen at Copenhagen was altogether more severe than that with which I am familiar, but it is difficult to be sure that the type of disease is more severe, as the reputation of Finsen's Lysinstitut is so great that all the old and uncured cases find their way there.

"The light treatment up to the present has only been applied to, beside the skin, the lips, gums, hard palate, tongue, septum of the nose, and guardedly to the eyelids. The results of the application of light to lupus of the mucous membranes have been favorable. Other local remedies to these parts are also applied, especially the electric cautery: strong solution of iodine, and lactic acid are used to the gums, and tampons of mercuric chloride to the nostrils. I was much convinced of the great importance of very frequent local measures being employed to the affected mucous membranes.

The application of light excites a degree of inflammation of the tissues treated, varying very much with the susceptibility of the patient. Whether this inflammation is a specific reaction is open to discussion. I think probably not, but that it depends more on the idiosyncrasy of the individual, as the reaction varies much in cases equally typically Lupus vulgaris, and as Erythema solare is excited by the chemical rays in the healthy skin. In most cases the inflammation is slight and no pain is caused, but in some vesicles and bullæ are produced. The inflammation is much less when sunlight is employed than when the arc-light is used, as it has to be during the greater part of the year. When severe the treatment has to be suspended for a time if the patch is small, or applied to another part if the disease is extensive, so that the inflammation may subside. Erysipelas occurs in some cases under the light treatment, as it does under other methods, and also in lupus not under treatment. This was the case more frequently at a former period, but *since each patient has had applied a boric-acid ointment, and the part protected by a bandage after each application of the light before leaving the Lysinstitut, its occurrence is much less frequent.*

"Patients report themselves periodically after their discharge for inspection, to ascertain if the arrest of the disease is complete. It often happens that lupus nodules that had been overlooked from being deeply situated, or masked by the inflammation excited by the treatment, are detected, and these cases are again treated for a short time. As to recurrences, it is difficult to speak; but I saw cases where there had been no recurrence after one year's and two years' discontinuance of treatment. Of course, reinfection is as possible as primary infection. Like all other methods of treatment, the light treatment is not equally suitable for all cases of lupus. Some would be more rapidly, if not more effectually, treated by surgical measures as perfected by Lang, and which are becoming more generally employed than a few years ago. But the ordeal of an operation, and the risk of an anæsthetic, infinitesimal as it is, have to be weighed against this. I have no experience of the treatment by Roentgen rays, or the hot-air treatment. But as compared with the treatment by erasion, and the application of escharotics, the light treatment yields far better results, in my opinion, and for this reason that it is selective in its action, killing the bacillary exciters of the granulation-tissue, without destroying any tissue, diseased or healthy. It is applicable to all cases, and better than most other methods of treatment for the majority of cases."

A writer in *American Medicine*, November, 1901, remarks that in the London hospital to which a Finsen apparatus was presented by the Queen, *the number of cases awaiting treatment was so great that two years must elapse before they could receive attention.* Lupus is estimated to constitute about only two per cent. of all skin diseases in England, and is even less common in this country.

On December 9, 1901, a paper by Dr. Bangs stated that "over six hundred cases of lupus have been treated in Copenhagen, with positive results in ninety-eight per cent. of the number." Late reports are not at hand, but for reference and comparison we present a few cases described by Dr. Bie in earlier publications. New lamps now give better results in one quarter of the time with a quarter of the current.

Lupus Vulgaris.—"No. 192 (Fig. 8), thirty years old. Lupus vulgaris faciei et cavitatis nasi. The patient has been suffering from lupus vulgaris fifteen years. Previous treatment: (1) cauterization of the lupus; (2) homœopathic treatment; (3) scraping out and thermo-cauterization during three years. The disease was progressing very slowly just before the beginning of the treatment. The extent of the disease is seen in Fig. 8. The affected places were swollen and red. Everywhere numerous nodules, partly confluent, with crusts and small ulcerations, no large ulcers. A number of disseminated nodules in the healthy skin. There was an extensive but almost quiescent lupus cavitatis nasi.

"June 1, 1898. Treatment by light with a quartz apparatus and a lamp of fifty amperes one hour a day. For the mucous membrane of the nose: Compresses saturated with a solution of perchloride of mercury and touching with a solution of iodine and iodide of potassium (1:2:2) once a week.

"September 30th. Steady improvement. No ulcers at present. The skin of the nose seems to be healthy. Everywhere good scar-tissue; hardly any nodules visible.

"October 29th. No distinct nodules. Treatment discontinued.

"November 15th (Fig. 9). Everywhere the scar-tissue is smooth and but little visible. No distinct nodules.

"January 19, 1899. Letter from the patient's doctor. No relapse.

"No. 84 (Fig. 10), twenty-three years old. Lupus vulgaris faciei, cavitatis nasi et manus dextræ, phthisis bulbi dextri; spina ventosa digiti iii sinistri. The patient has been suffering from lupus for seven years. Previous treatment: (1) ointment; (2) scraping, several times repeated; (3) touching with iodine. There was lupus on both sides of the face and of the right hand. The extent of the disease on the left part of the face was about the same as on the right half of the face, as shown in Fig. 10. The dorsum of the right hand was affected to the half of its extent, and still a part of the right fourth finger and the fifth one. The lupus consists of ulcers, covered with crusts, and of disseminated non-ulcerated nodules. The right ala nasi was almost quite destroyed.

"October 18, 1897. Light-treatment of the face, alternating every two days with lamps of thirty-five amperes and glass apparatus during two hours, and lamps of fifty amperes and quartz apparatus during one hour.

"February 19, 1898. Hardly any improvement.

"March 8th. A slight improvement only.

"April 13th. Good improvement. The apex nasi is not ulcerated. The ulcers of the cheeks are less numerous, small, and superficial.

"May 17th. The affection of the face is constantly improving, no ulcers, a few disseminated nodules.

"June 15th. Light-treatment one hour every day with a lamp of fifty amperes and a quartz apparatus.

"August 18th. The affection of the face apparently cured. No distinct nodules.

"October 25th. A fine scar-tissue everywhere in the face. Still a few doubtful patches. Treatment discontinued.

"November 11th. The scars on the face are sound, only two small solitary nodules on both cheeks. Light-treatment a few times.

"May 24, 1899 (Fig. 11). Everywhere a smooth and pale scar-tissue; the small scars are but very little marked. On the right cheek three small, fresh, and doubtful nodules; otherwise no nodules.

"The right hand is treated by light (a lamp of fifty amperes and a quartz apparatus) from October 25, 1898, till January 16, 1899; in addition a pyrogallic-acid ointment is applied five times, three days.

"May 24, 1899. The hands were covered with a smooth scar-tissues still a little red, but without any nodules.

"No. 143 (Fig. 12), aged twenty-two. Lupus vulgaris faciei et laryngis. The patient has been suffering from lupus about six years. Previous treatment: (1) ointments; (2) cauterization; (3) excision with transplantation three times; (4) scraping. The disease had been spreading quickly shortly before the treatment. The affected part was much infiltrated, of a deep livid color. There were many irregular partly confluent ulcers, flat, with prominent granulations. The skin between the patches was thin, smooth, and shining. On the nose only a few nodules; they were somewhat more numerous on the margin, on the cheeks and the lips. The greater part of the cartilaginous structure of the nose was destroyed. The upper lip was much infiltrated, the prolabium somewhat crusty, but it semed to be free from lupus. The gums at the incisor teeth were swollen.

"February 19, 1898. Light-treatment, alternating every two days with a lamp of fifty amperes and a quartz apparatus during one hour, and a lamp of thirty-five amperes and a glass apparatus during two hours. Tampons with a solution of perchloride of mercury in the nose.

"April 6th. Considerable improvement, less redness and infiltration, only a few ulcers. The upper lip not swollen any longer.

"May 25th. Steady improvement, hardly any ulcers; the swelling and redness are disappearing; only a few nodules.

"June 15th. Light-treatment every day during one hour by a lamp of fifty amperes and a quartz apparatus.

"August 18th. No ulcers; only on the alæ nasi a few brownish patches; no distinct nodules. Treatment discontinued.

"Next time the patient was examined, on November 15, 1898, the skin was smooth everywhere, the scar-tissue fine. There was only one nodule on the right side of the nose and one on the right cheek; these were treated a few times. Since treatment was left off in August an ulcer has developed on the right side of the prolabium of the upper lip; it is seen on Fig. 13; the photograph was taken on November 15, 1898. The whole right part of the upper lip was swollen. This ulceration was very obstinate; it was treated during a certain time by light in December, 1898; and since then by galvano-cauterization twice; it was also scraped once. It has now diminished to about the size of a pea.

"February 2, 1899. A little brown nodule was observed on the left ala nasi; it disappeared by galvano-cauterization.

"May 3d. The scar-tissue of the skin is fine; there are no nodules.

"No. 177 (Fig. 14), aged sixty-five. Lupus vulgaris faciei et cavitatis nasi. The patient had been suffering from lupus for ten years. Previous treatment: scraping three times during the first year of the disease; later at irregular intervals. There was a very considerable infiltration and hypertrophied granulations. Everywhere irregular, nodular ulcers were visible, forming large, confluent surfaces, between which nodules of the size of a pea. In the neighborhood numerous nodules and small ulcers.

"April 18, 1898. Light-treatment, alternating every two days with a quartz apparatus, and a lamp of fifty amperes during one hour, and with a glass apparatus and a lamp of thirty-five amperes during two hours.

"From June 15th. Light-treatment with a quartz apparatus and a lamp of fifty amperes every day during one hour. The treatment was continued till October 17th. In addition pyrogallic acid ointment was used in some of the periods, when the affected parts were not treated by light, altogether six times on the right cheek, four times on the left, and once on the nose. The treatment by ointment lasted every time about three to four days.

"October 17th. Treatment discontinued. There was everywhere a smooth, soft scar-tissue; no distinct nodules.

"December 3d. Letter from the patient's doctor: 'On the margin of the left ala nasi a tiny ulceration, covered with crusts, with doubtful nodules. The remaining part of the affected area, the nose as well as the cheeks, is covered with a smooth scar-tissue.'

"January 13, 1899 (Fig. 15). Note made in the clinic of the Institute. There is a smooth, rather bright scar-tissue everywhere; the left cheek is the best, with only a few nodules; on the right cheek also but a few nodules; but, besides, some suspicious spots of pigmentation. On the root of the nose a couple of superficial small nodules; the soft part of the nose is a little swollen and red; there are some deep spots of pigmentation; on the margin of the left nostril a few small ulcerations. In the interior of the nose lupus still exists. Light-treatment with a quartz apparatus, and a lamp of seventy amperes one hour every day.

"February 11th. Treatment discontinued.

"March 10th. Letter from the patient's doctor: 'Quite well at present; no sign of relapse.'

"The principal advantages of the method are, besides its reliability, its excellent cosmetic results, the infrequency of relapses and their slight extent, and the fact that the treatment is painless. The good cosmetic result is due to the fact that there is no destruction of tissue, healthy or diseased. It is for the same reason that the results in respect to relapse are so favorable. One may, without harm, treat both the diseased tissue and the apparently healthy surrounding skin until one is fairly sure of having destroyed all the disease germs. When the patient has been treated till there are no distinct nodules of lupus to be seen at the moment, the treatment is discontinued, till the swelling and redness of the skin have disappeared, so that it is easier to determine whether anything is left of the disease or not. If there is nothing visible, the patient is still kept under observation. Many have, however, to be submitted to a second course of treatment. Whether the nodules which develop are the result of recurrence, or whether they could not earlier be recognized as lupus nodules, is a matter of little consequence in itself. The principal thing is that there have always till now been a few scattered nodules, which disappear after a short further course of treatment.

"If the treatment is carried on for some time after the last nodule of lupus seems to have disappeared, recurrence would be more surely guarded against. The fact that the treatment is discontinued as soon as we think it justifiable to do so is due solely to the desire to save the time and the money of the patients as far as possible. Inasmuch as the efficacy of the treatment is absolutely certain, and the patients, on account of its painlessness, are very willing to submit themselves to a second course, a recurrence is not nearly so serious a matter as it is after the older methods of treatment.

Lupus Erythematosus.—"The treatment of this disease has in many cases given excellent results—permanent recovery and firm scars. Nevertheless, the effect of the treatment is not nearly so sure as it is in the case of lupus vulgaris. A few cases have improved very slowly and with a constant tendency to recurrence. What the cause of this great individual difference may be it is still impossible to determine, if for no other reason because we have not a sufficiently large material (altogether only twenty-eight patients).

Alopecia Areata.—"As the indication for the treatment by concentrated chemical rays of light is that the disease must be superficial, local, and bacterial, and as it is at least possible that alopecia areata is due to an infection, we have tried to treat this disease. In January, 1899, when the first experiments were published in Danish, seven cases altogether had been cured. The following are the notes of one of the cases:

"No. 65, aged fifteen. In the beginning of June, 1897, the patient noticed a bald spot about one centimetre in diameter, which was steadily increasing. When the treatment began on September 3, 1897, there was a large completely bald spot of six by four centimetres. After shaving the areas immediately surrounding, the patient was treated eight times for about half an hour from September 3d till September 24th.

"October 4th. Lanugo hair on the patch.

"November 5th. A normal growth of hair.

"January 12, 1898. A bald spot of two and one-half by two centimetres is seen.

"Treatment five times one hour from January 12th to 16th.

"January 22d. Fine small hairs.

"March 29th. The growth of hair is as vigorous as on the rest of the scalp.

"October 22d. Unchanged."

In October, 1900, another visiting physician from this country wrote that at the Finsen Institute he had seen a case of "a large fungating cancer of the neck at least five inches in diameter, first removed by the knife and the base then treated with photo-therapy." The patient obtained a "healthy" cicatricial tissue, and examination indicated that a "cure" had been accomplished in this case.

It is the opinion of Morris and Dore, in England, after extensive experience with the Finsen light treatment of lupus and rodent ulcer "that this treatment may fairly claim to rank as second to none in importance and utility," and the same authors are "confident in hoping that light used in this way will not only give better results in lupus and other intractable diseases of the skin, but more permanent benefit than any form of treatment hitherto employed." These views were expressed a year ago before newer lupus lamps had demonstrated very much quicker results than the early lamps of Finsen. Of the new lamp, using only about one-fifth the current of Finsen's large arc-light a skilled dermatologist in Europe, with experience in both X-ray and Finsen treatment of lupus and rodent ulcers, writes me under date of October 28, 1901: "The introduction of the new lamp will certainly take the place of the X-rays in the treatment of all cases of lupus where it is possible to apply pressure; but for cancerous affections of the skin the X-rays are superior, as my results have proved." This verdict must also apply to lupus, etc., affecting mucous membranes, and areas which size or situation puts beyond the Finsen method.

Finsen's Photo-chemical Therapy.—Finsen's modern Photo-therapy exactly reverses his practice of 1895, which used light *deprived* of its chemical rays in the treatment of exanthemata; rejecting the actinic rays because of "their power to cause inflammation of the skin." This once rejected property is now used as the more important curative agent in composite light, both of the sun and electricity; and with means of rational dosage a great therapeusis is developing effective methods. Unless otherwise stated we will consider that the term "Finsen's therapy" in this section signifies only the treatment of local superficial parasitic skin diseases by focussed and filtered luminous-and-chemical rays, and not luminous-and-heat rays, which constitute an entirely different therapy for us to discuss in turn. The terms actinic, chemical, blue, violet, and ultra-violet, as applied to rays of light refer practically to the same thing—to the same general group of rays—in the medical literature of this subject. Exact science differentiates closer, but the physician need not. Finsen's Therapy and the developments from his pioneer work rest on three *proven facts:*

1. Chemical rays of light will destroy bacteria.

2. It is the chemical rays that produce sunburn, and they will cause inflammation.

3. The chemical rays will penetrate the skin, even photographing a landscape through the entire body.

From these general facts to the concrete application of them in the cure of disease is a matter of *dosage.* The deodorizing and antiseptic properties of light, and wholesomeness of its action on sick people was not questioned; but there were two matters for clinical study, and they have been studied by great investigators:

1. Did the germicidal power of light reside in whole white light or in *a special part* of the spectrum?

2. Could the antiseptic action of light, ordinarily slow, be made to destroy bacteria *quickly?*

The first question has been decided by the elimination of green, yellow, and red rays, and what are now known as the chemical rays are accepted as the main therapeutic agency in this treatment. The second question opened many difficulties which have been partly solved by electricity, lenses, and mechanical devices, but the future of photo-therapy in private practice will rest on the further development of facile, simple, and effective apparatus, of which the recent nascent stage of construction was the promise rather than the substance. Light-rays are certainly *therapeutic,* but the use of them will appeal to average therapeutists only when they present a ready, simple, inexpensive, and effective means of securing results that are beyond methods already installed in common use. The value of results so far demonstrated has been somewhat impaired in the estimation of the general profession because of the difficulty of the treat-

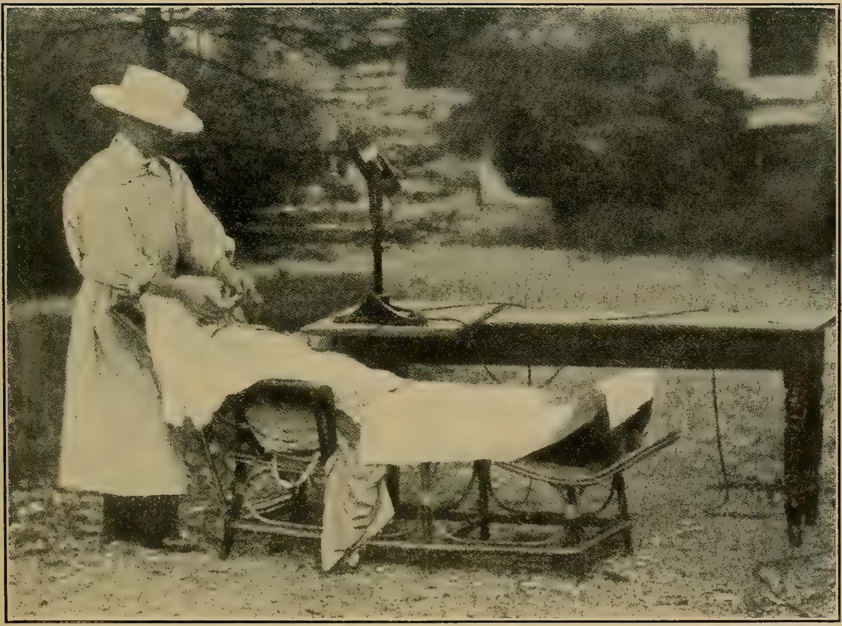


PLATE 193.—This plate shows the sun-lens on the table, and the attendant holding the "compressor" on the lesion. A scene in Finsen's Institute. It is more than probable that, cheap as sunlight is, when it can be had, yet new strides in vacuum-tube light at low cost will displace all other mechanism in photo-therapy. Such a picture as this will become historical and reminiscent.

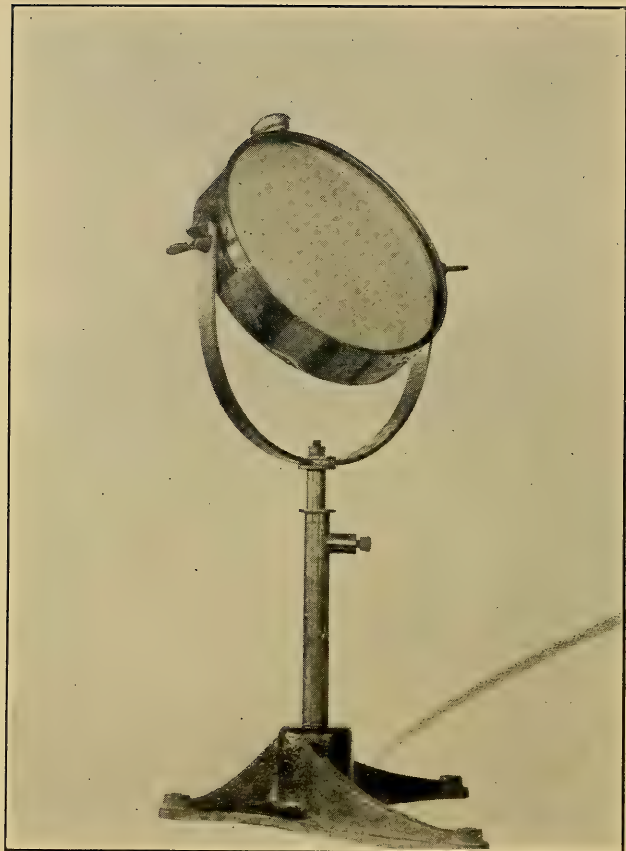


PLATE 194.—Finsen's Lens for Sun's Rays. It is only when light is concentrated in such a way that it contains as many blue, violet, and ultra-violet rays as possible that its bactericidal property becomes so powerful that it can be used therapeutically with advantage. To avoid burning the skin it is also necessary to cool the light, and this filtering lens serves the double purpose. It consists of a lens of about twenty to forty centimetres in diameter. The lens is composed of a plain glass and a curved one, which are framed in a brass ring, and between them there is a bright blue, weak, ammoniacal solution of copper sulphate. As one surface of the liquid is plain, the other one being curved, its optical function is that of an ordinary plain convex glass lens. By making the lens of a blue liquid instead of solid glass a considerable cooling of the light will be obtained, because water absorbs the ultra-red rays, and because the blue color excludes a considerable amount of the red and yellow rays. These three kinds of rays have particularly strong heating effect, while their bactericidal power is insignificant. On the other hand, the blue, violet, and ultra-violet rays, which it is important to procure in as great a number as possible, are but very slightly impaired by passing through the blue liquid. The lens hangs on a foot, made in such a way that the lens can be raised and lowered as well as turned on a vertical and horizontal axis; therefore it is easy to place the lens perpendicularly on the sun rays, and at such a distance as to make the light strike the area of the skin which it is intended to treat. All the pictures in this series were sent to the author by Dr. Finsen personally, and their reproduction authorized.

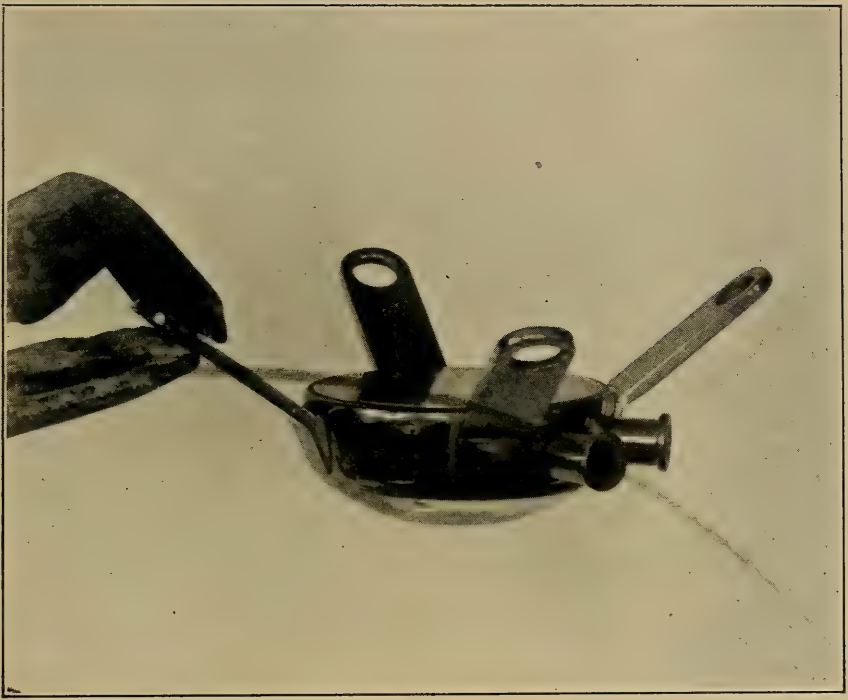


PLATE 195.—Finsen's Compressor of Rock Crystal. Rays from either the large electric arc or the sun, even after passing through the filtering lens, are still too warm for use on the skin. Blood in the surface vessels also hinders penetration of the rays, hence this device is employed to cool and compress the tissues. It consists of an upper plate of quartz and a lower plain convex lens of quartz, both framed in a conical brass rim which carries two tube-holes for the circulation of running cold water between the upper and lower quartz, and four short arms for elastic bands by means of which the compressor is held in close contact on the part. Rubber tubing is attached from a water bag or faucet to the compressor, and during treatment the flow is kept continuous to cool the skin so that it can stand the strongest light. By pressure of the convex quartz on the skin the surface vessels are made anæmic, and this promotes the penetration of the chemical rays, as taught. In this manner an area of skin of about one and one-half centimetre in diameter is treated for an hour every day except Sunday. Large lenses of crystal are desired, but the cost is prohibitory. Newer lamps giving "cold" light will remove this feature.

PLATE 196.—Examples of Finsen's cases before and after treatment.

ment, the time required, and the first cost (and cost of operating), the apparatus in regions where sunlight must give way to electricity. But if the prospect of overcoming these primary drawbacks is good the subject will interest us all and photo-therapy will find uses in nearly every office. Were it not apparently certain that this event will come about, this section would not now be written, but so much has been done and so much is undergoing a promising evolution in the essential mechanism of dosage that we may well study here the basic principles in brief, and when the apparatus comes we shall be ready to use it. Some of it is here now in quite a satisfactory state, and each year is a year of advance in electricity.

The basic principles relate similarly to the use of the sun's rays and electric-light rays, and, if the sun shone always in every office we would need no other source of light. But in electric-lights there is an immense difference in the proportion of chemical rays per candle-power, or in the totality of the lamp, and on this account the given lamp must be made for the purpose of its therapeutics.

1. The light must be rich in chemical rays and concentrated to have therapeutic energy.

2. It must be cooled to avoid burning.

3. The cooled and concentrated rays must be brought close to the part and focussed on the lesion, and to be most effective the field under treatment should be made anæmic by pressure on the skin to empty the superficial capillaries. The little device for doing this is called a "compressor." Much blood makes the tissues less transparent.

Concentrating and focussing light-rays is familiar to every schoolboy who has ever played with a reading-glass, and needs no mention beyond stating that such lenses are a part of Finsen's apparatus. Few physicians, however, who know how a lens will set wood on fire know how the focus is reduced to merely comfortable warmth for safe application to the skin in a long séance. Let us make this plain to the reader. Make a brass mounted convex glass lens as follows: in the face of a brass rim fix a curved glass pane, and in the back of the rim fix a flat pane; drill a hole through the rim and fill the space between the two panes of glass with a weak ammoniacal solution of copper sulphate, just strong enough to color it a bright blue, and stop the hole with a cork. This makes a convex lens. Hold it over the skin so that the sun's rays will pass through it and be concentrated to a focus. The water between the two panes of glass absorbs most of the ultra-red rays, and the blue in the water excludes most of the red and yellow rays, and *heat* is almost all produced by these three kinds of rays. By keeping them from the tissues the rest of the light is cool. The blue liquid does not very much reduce the blue, violet, and ultra-violet rays, and they pass to the tissues in nearly their full dosage. (Plate No. 194.)

With electric-light rays the method is a little different, because all the sun's rays reaching us are long enough to pass through the glass and blue solution, while a similar obstacle would stop many of the shorter rays of electric-light. Therefore, only plain distilled water is put betwen the two panes which filter the rays (or, alum may be put in the water) and, instead of glass which stops many of the ultra-violet electric rays, quartz is used when possible, as it lets these important rays pass more freely. As the water thus in the path of the rays heats up when a powerful lamp is used it is kept below boiling-point by allowing it to flow to and from a pair of suspended water bags, or is kept circulating by some other device. A filter made of *glass* panes and filled with a blue solution will greatly lower the efficiency of a very high candle-power electric lamp, and the greatest efficiency is obtained by colorless water and rock-crystal filters. Additional cooling of the skin is produced by the "compression" which, in the Finsen technic, assists to make the part anæmic. See description accompanying illustration. (Plate No. 195.)

With the Finsen apparatus in its early period, or prior to recent improvements, an area of skin about six-tenths of an inch in diameter could be treated at a time, and was usually given a séance of one hour every day. The limited field of application, the tedious time required, the long duration of attendance needed, and the fact that a costly apparatus feeding on fifty to eighty amperes of current was the only substitute for the sun, tempered the imitative furore of those who were gratified by the results. The *quality* of the results was such that, despite the length of time consumed and the fact that only small and accessible lesions were treated, the method held the attention of Europe for three years. The X-ray and direct static sprays, high-frequency discharges, etc., then showed about the same results in far less time and with much greater facility, till in the summer of 1901 a new "lupus lamp" took precedence over earlier models and reduced the exposure-time to less than a fourth of Finsen's. (See Plate 201.)

Experimental Data.—On the evening of May 11, 1897, Finsen exposed the normal white skin on the inner side of his own left forearm to the whole rays of an eighty-ampere arc-light placed vertically over the part. The exposure was ten minutes at twenty inches distance, when it got too hot for tolerance. The arm was then removed to thirty inches and ten minutes further exposure was made—a total of twenty minutes. The arm was specially prepared for the study of effects and Finsen estimated the intensity at over 40,000 candle-power. In 1901 he made the following report: *

"The point was to expose the skin so that certain parts would be acted on by *all* the rays, while other parts would be under the influence of certain special parts of the spectrum only. I placed on the arm a plate of quartz, a series of different colored glasses, stripes painted in india ink, and an ointment the protective action of which I wished to ascertain. These were placed on the arm in such a way that the skin around them was freely exposed to the whole light and thus a comparison of the different actions could be made. The quartz was one and one-half millimetres thick. The pieces of glass were two millimetres thick and were red, yellow, green, blue, and plain. The arm was covered as usual by the clothing except during the exposure to the arc-light. The skin showed at once some uniform reddening even on the parts which had been covered. Two hours later the color was a little paler but still red all over. At the end of three hours the reddening had increased, but only on the places which had *not* been covered. The difference was, however, very slight.

"Next morning the tracings on the skin were plain. The skin was now quite dark red and hot, and somewhat tender to touch, but where it had been covered by india ink it was white and normal, in marked contrast to the surrounding red. Under the ointment and five strips of glass there were equally white normal stripes, but where the *quartz had been the skin was as hot and tender and red as where no covering at all had been.*

"The reddening remained well-marked for some days and then gradually receded. When the redness had nearly disappeared the skin began to peel off like bran. This lasted six days. The skin was then pigmented so that the stripes made a strong contrast of white on a brown ground. This faded for several months, and by October was scarcely perceptible. My experiment shows the different action on the skin of *heat* rays and the *chemical* rays. Heat immediately reddens, attains its maximum at once, and then abates to the normal color of the skin. The chemical rays produce no color at first. This appears only after several hours and takes twelve to twenty-four hours to reach its maximum. In my test the heat was very strong during the first ten minutes, whereby the skin was immediately reddened but became much paler after two hours. This initial redness therefore depended on the heat rays.

"The redness that developed three hours after the treatment (an hour after the heat reddening had abated) was due to the action of the chemical rays on the skin. The test of the letters showed how absolutely *local* and sharply defined is the inflammation caused by these chemical rays. The brown ointment and the india ink protected

* Condensed from the Journal of Physical Therapeutics.

the skin by their color, but the skin was equally uninfluenced under all the layers of glass, regardless of colors used.

"The results under the various glasses strikingly proved that *the redness of the skin depended exclusively upon the action of the invisible rays beyond the violet of the spectrum, and that the visible chemical rays had not produced any effect whatever.* But the conclusion to be drawn from this is not that visible chemical rays *cannot* produce any photo-chemical inflammation. Simply, the dosage was insufficient. It is a daily experience in the treatment of skin diseases with concentrated light that the visible chemical rays, even after filtering through thick glass lenses, can and do produce the inflammatory reaction, with the arc-light as well as sunlight. Even when the light has to pass not only through the four thick glass lenses of the concentrator, but through a solution of methylene blue or an ammoniacal solution of copper sulphate (which absorb the greater part of the ultra-violet rays) there frequently appears an evident and sometimes pronounced photo-chemical inflammation followed by pigmentation. To test this point I made further experiments on my own arm. . . . The results showed that the skin reacted with the usual inflammation, as follows:

"1. Through a *quartz* cooler, most strongly.

"2. Through a pane of clear *glass*, less strongly.

"3. Through a pane of blue *glass*, least strongly.

"4. Through *glass* filters of other colors there was no action whatever.*

"In these tests the red marks on the skin were raised above the surface like flat hyperæmic spots with the border raised sharply over the normal skin. There were no blisters, and the elevation was not due to loosening of the epidermis. These experiments not only confirm but extend Widmarks's observations. Widmarks's splendid series of experiments, which I have repeatedly referred to and which for the first time afforded scientific proof that it is the ultra-violet rays that produce light-erythema, show the great difference in light action through glass and through quartz. A glass pane absorbs, as is well known, the greater part of the ultra-violet rays from the electric arc-light, while white quartz (rock crystal) panes allow such rays to pass.

"The powerful influence of heat and cold upon the expansion and contraction of blood-vessels and capillaries is not likely to be underestimated, but the effects of *light* are not so fully appreciated. Resulting from the single twenty-minute exposure on my arm I observed that the capillary dilatation could be shown by rubbing the skin even five or six months after the pigmentation had disappeared. That the chemical rays produce dilatation of the capillaries I had previously demonstrated by microscopic observation on the tail of tadpoles, and that this action with modified exposures has a certain advantageous

* If the student will fix these facts in mind it will make clear some of the needs of a good apparatus. The media used as a filter may rob an otherwise fine apparatus of half its dose-efficiency. Do not forget this.

influence scarcely admits of doubt. It may be presumed that there will flow, or at least that there *can* flow, more blood to the skin when the capillaries are distended, and that this improves the nutrition of the skin and makes it more able to perform its functions. If this be the case, as it no doubt is, that a more frequent but less intense illumination than was made on my arm has the same effect on the skin capillaries, we must expect to find more blood (or more capacity for blood-supply) in those parts of the skin that are exposed. These facts are demonstrated."

"Let us now further consider the cutaneous redness produced by *heat*. There are two kinds: direct and indirect. The direct action is the heat erythema which appears on the local application of strong heat, and depends on a paralysis of the muscular coats of the cutaneous vessels. It differs from the erythema of chemical rays in occurring immediately during or after the exposure, and in disappearing in a short time proportionate to the intensity of the dose. The indirect redness is that which occurs from an increase of the body-heat and the consequent determination of blood to the skin. Repeated action of this kind does not increase the permanent redness of the skin. From an elaborate study of the effects of cold under many conditions we find that cold *per se* has no lasting effects on the vascularity of the skin. But experience shows that *light* in conjunction with both heat and cold modifies the effects and is a decisive factor in actions generally attributed to heat and cold alone. In conclusion, the following points have been established by this series of investigations:

"1. I have confirmed the results of Widmark's researches on the action of light upon the skin, and further proved that the visible chemical rays as well as the ultra-violet have the power to produce specific photo-chemical inflammation of the skin.

"2. I have shown that in the electric-light the strongest bactericidal power resides in the ultra-violet rays, and, as a practical conclusion of this, it follows that *quartz lenses only and exclusively should be used in electric-light concentrating apparatus.* The substitution of quartz lenses for the now obsolete glass lenses has immensely advanced the treatment with concentrated light.

"3. I have shown that the capillary dilatation caused by ultra-violet rays is long lasting, being detectable even half a year after my own test exposure.

"4. Comparison of the different factors acting on the skin has shown that the normal reddish hue which the uncovered skin acquires is wholly or in great part produced by the chemical rays of light.

"These third and fourth observations mean a great advance in the study of the physiological action of light upon the skin. We have taken a long step forward, and it only remains to know the exact signification and importance of an abundant blood-supply to the skin. We are entitled to presume that the skin is better nourished and more able to perform its functions, and when we arrive at a definite knowledge of these we will then, without doubt, arrive at the conviction that we have in the chemical rays of light a resource—perhaps the most powerful known to us—whereby (in the form of light baths) we can enhance the functions of the skin."

When high-intensity arc lamps are used for the local photo-chemical reactions of Finsen's therapy (as distinguished from the general actions of photo-therapy), the physician must use a proper filtering medium or he will lose most of the power of his lamp. The ascertained facts as to absorptive power of different media are, according to Larsen, as follows:

1. Clear glass allows about ninety per cent. of the visible chemical rays to pass through it.

2. A thin pane of red glass lets through about eighty per cent.

3. Red glass lets through twenty-eight per cent. of the outer red rays, twenty-three per cent. of the middle rays, four per cent. of those next the yellow, and absorbs all others.

4. Yellow-red glass lets through thirteen per cent. of red rays, two per cent. of yellow rays, two per cent. of green rays.

5. Green glass allows a trace of yellow rays to pass, fourteen per cent. of green rays, and a small amount of blue rays.

6. Blue glass lets through thirty-three per cent. of the upper red rays, three per cent. of the remaining red, and about seven per cent. of the yellow.

But this relates only to the visible part of the chemical rays of the spectrum. Not only do media of colored glass shut off so much of the desired rays from the tissues as above stated, but colored glass and *blue solutions* cut out practically all the more important invisible chemical rays of the arc-light. This means in practice that when a patient is treated with ever so large a lamp but through a glass cooler filled with blue water the exposure will be reduced to a very feeble dosage. More efficient dosage will be obtained with a filter of thin clear glass filled with clear uncolored water kept flowing to cool it. But the most efficient dosage of the electric-light, the only one which really secures the ultra-violet and full energy of all the chemical rays, is the clear crystal filter of polished quartz. Next to having a lamp of high-intensity rich in chemical rays, and using it at close proximity to the lesion, the crucial feature of a lupus lamp must be considered the filter. In the study of photo-therapeutic apparatus look well to this point. In Bie's classical paper on Finsen's photo-therapy, published in September, 1899, he takes occasion to remark: "It must further be taken into account that until a year ago apparatus was used (in the Finsen Institute), the bactericidal effect of which was quite insignificant compared with that now employed, *because the lenses were of glass instead of quartz.*"

The following involuntary contribution to the physiological study of high intensity chemical and heat rays of light was reported from Niagara Falls, December 29, 1901. Compare the intensity of action of Finsen's seventy-ampere arc, giving 40,000 candle-power, with this arc of 350 amperes at 220 volts giving 308,000 candle-power, the highest on record.

In the Furnace Company's works a method of burning holes in masses of "salamander" with an electric arc was substituted for the usual and slower drill. The carbon was six feet long and two inches in diameter; the rheostat was immersed in a barrel of running water to keep it cool; when the current of 350 amperes at 220 volts was turned on an arc was made that could be extended to six inches, and the light equalled about 308,000 candle-power. It was equal to 160 street arc-lamps. Every one who looked at the arc for even a very few minutes had a severe inflammation of the eyes with the exception of two men who wore plain white-glass spectacles, and they suffered no inconvenience whatever, although one of them looked at the light a great deal. Says the engineer in charge: "I was affected worse than any of the others, because I stood within ten feet of the arc and looked at it more than any one else. After the first exposure to the arc I rode home on my wheel, and, before reaching home, was nearly blind and in terrible agony, and consulted a physician immediately. My eyes were bloodshot, and the lids so inflamed that the eyes were completely closed. My eyes were kept bandaged and treated with an eye-wash alternated with witch-hazel lotion, but suffered a great deal for four days. The skin of my face all peeled off except where protected by hair. Under the shade of the hat the skin peeled less, but still quite severely.

"The next morning ten or twelve of the foremen and employees complained of similar trouble. In fact, every one who looked at the arc, except the two who wore glasses, were more or less severely affected. Some were laid up totally blind for a day or two. Others were laid up only half a day, while several who came to work the next morning worked with great difficulty on account of the pain and inflammation in their eyes. We then wore a mask with white glass, 'stone-cutter's goggles,' and, though there was still a little inflammation in our eyes from close and continuous work, yet we did not suffer as before."

Technic of Finsen Lupus Method.—Whatever modifications in technic may come about through improved apparatus, and especially through the desirable substitution of small currents for the large amperage of Finsen's lamps, it seems certain that the principles of administration as worked out by him will remain with us for some time. The most instructive description we have so far seen is that of Morris, which is herewith given: *

" *Care of the Filter.*—The lenses, especially the bottom one, must be clean and bright. The water in the filter must be changed daily and must be clear. Ordinary clear water gives as good results as distilled water.

" *The Focus.*—The area treated is usually kept well within the focus of the light, but if a smaller focus can be borne it has a greater effect.

" *Screens.*—The rays should fall *perpendicularly on the compressing device.* By fixing a metal screen to the end of the tube (of the Finsen apparatus) the least deviation of the compressor from square with the axis of the rays will throw light on the screen, and the position can be rectified.

" *Pressure.*—Elastic bands are used to hold the compressors on the part when possible. They are somewhat more painful to the patient than hand pressure, but insure even and firm pressure during the whole of the sitting; a thing difficult to maintain with the fingers. Elastics also obviate the need of a nurse to hold each instrument when many cases are treated at the same time.

" *Preparation of the Patient.*—The crusts are removed with forceps, then the area to be treated is bathed with boracic lotion, and if there is any grease on the part, with ether. The skin is then marked with a blue pencil so as to ensure the light being applied to the same spot. After treatment the compressors are cleaned with alcohol and carbolic acid. The diseased surface treated is dressed, if necessary, with a simple zinc-lanoline ointment, or a paste with zinc-vaseline and a little boric acid.

" *The Reaction.*—This largely depends on the intensity of light at the time of the exposure, and this in turn depends on many factors, such as the exactness and size of the focus, the clearness of the lenses and water of the filter, the quality and even burning of the carbons of the arc, etc. The reaction will further depend on the depth of the disease, the amount of scarring, pigmentation, and vascularity.

" *Time of Onset of Reaction.*—This varies from five to twenty-four hours. It is generally noticed the morning following treatment. It is usually slight for the first few days and then becomes more marked. It does not appear to diminish in intensity after continual treatment, but if anything to increase. After a preliminary hyperæmia with slight redness a bleb forms, bursts, and dries, to form a yellow crust at the end of about a week, and in ten days or two weeks

* The current exciting the arc lamp used by Morris was seventy-five amperes of sixty volts, but as newer lamps gave better results with less current and shorter exposures we omit his references to current strength.

the sore has completely healed. When situated over loose tissues (for example, over the eye) there is often great swelling of neighboring parts.

"Experience shows that the beneficial effect produced varies directly with the intensity of the reaction. The same principle seems to apply in the case of ulcer as in lupus. When the epidermis is absent there is no blistering and crusting as when the skin is intact, and many more consecutive applications can be borne on a single spot. The reaction then shows itself by redness and soreness, with perhaps some swelling of the surrounding parts and great tenderness on pressure. This supervenes about the fourth or fifth day, and if the treatment be continued the skin around the ulcer becomes inflamed. Of all the diseases amenable to light treatment, lupus vulgaris is most benefited, but the treatment cannot be regarded as a specific, and we cannot go so far as Dr. Bie, who regards as doubtful the diagnosis of cases which do not respond to it. That it has a marked effect upon rodent ulcer and other diseases does not disprove the bactericidal theory of its mode of action, although it negatives the supposition that it is specific for the tubercle bacillus alone; apparently there is some chemical or nutritional effect upon the tissues also to be taken into account. In all the cases we have treated, the improvement has been marked and uniform, though in some cases very slow.

"*Effect in Lupus Vulgaris.*—In several cases a small isolated superficial nodule had disappeared after one application. As a general rule, and speaking broadly, it may be said that in an extensive case a single spot is treated daily, and the parts first treated are sufficiently healed in a few days to permit of treatment being renewed. If the area to be treated is only a small one the applications are continued as 'long as possible until the soreness of the parts and the crusts formed necessitate cessation of treatment for a few days. In an extensive case a year with intervals of rest may be given as a rough indication of the duration of the treatment.'

"In cases where there is much thickening of the skin the use of pyrogallic ointment will considerably lessen the duration of the treatment. We have used a five-per-cent. ointment in a few cases for about a week, and then after allowing the part to heal the light applications have begun.

"*Effect in Rodent Ulcer.*—In a case of extensive disease, where the typical hard edge was in places absent, the effect of a single application was apparently to stimulate healing of the part. In cases where there was no ulceration, reddening and perhaps slight excoriation of the skin resulted from a few applications, and the growth gradually becoming softer gradually disappeared. In small ulcers entirely surrounded by an indurated rolled edge there was no visible effect at first, but after several continuous applications the discharge increased and an inflammatory reaction occurred; at the same time the induration gradually disappeared until a simple 'punched out' ulcer with soft edges remained. On cessation of the treatment healing took place with great rapidity. The stimulating effect upon the tissues is marked in the ulcerations both of rodent ulcer and lupus vulgaris.

"*Effects in Lupus Erythematosus.*—The effect has been marked, but not so certain as in lupus vulgaris. In the more chronic cases, with much scarring, it is difficult to get a good reaction.

"*Constitutional Effects of the Treatment.*—Practically *nil.* (The application is strictly local.)

"*Effect on the Eyes.*—The eyes are carefully covered with protecting wool or paper, but the light can still be seen by the patient. There have been no deleterious effects upon the eye itself, but slight 'running of the eyes' has been experienced.

"*Effect on Mucous Membrane of Nose by Penetration.*—In one case in which the skin of the nose was treated, improvement took place in the mucous membrane, and the sensation of smell was said to have improved.

"*Unfavorable Conditions.*—Certain conditions make a case unfavorable for obtaining the best results by this treatment. These are:

"1. Those which *hinder the penetration of the chemical rays* and so prevent a good reaction. This cause covers scarring, pigmentation, great vascularity, great depth below the surface, thickness and induration of nodules, surrounding inflammation and induration, and confluence of the nodules.

"If the lesion has been previously scraped the cicatricial tissue is often dense, and a thick scar is nearly opaque to the rays. Brown ointment and india-ink made the skin under them immune from the rays in Finsen's test, and any pigmentation which intercepts the ultra-violet rays will lessen or annul the dose. Blood, arterial and red, is a red screen to the chemical rays to a certain extent, and, therefore, 'great vascularity' opposes treatment, and the area of the lesion must be rendered anæmic to secure an effective dosage. The reasons why depth and indurations reduce the therapeutic activity of a given amount of rays are obvious from the above.

"2. *Difficulties of Position.*—A lupus patch or other lesion may be suited to treatment, but be so situated that the conditions of photo-therapy cannot be well met. On the skin, for example, when the lesion is near the eye, special compressors may be necessary; or, if on the eyelid it may not be possible to apply adequate pressure at all. If on a mucous membrane, the interior of the mouth and nose are inaccessible to Finsen technic, but the gums and lips can be treated, the latter by everting them. In these cases the combination of X-rays with photo-therapy has been successful. Practically any surface and any mucous membrane affected with lupus can be reached by the X-rays, and pressures are ignored, though useful when convenient.

"3. *Extent of the Disease.*—As only small areas can be treated at a single exposure with the focus of a lupus lamp it is obvious that very extensive cases are unfavorable in practice. X-rays reach large cases without this drawback.

"*Disadvantages.*—To both patient and physician the disadvantages of Finsen's treatment have been the long time required, the small area treated at a time, and the expense. (Already these are lessened by newer apparatus and the technic is now on a much better basis.)

"*Favorable Conditions.*—Cases favorable to the method are those in which the area of the lesion is limited, is superficial, is not spreading, and has not had previous treatment, especially of an operative nature to thicken and scar the tissues.

"*Advantages of the Method.*—These are its reliability, painlessness, excellent cosmetic effects, the softness and non-contractility of the final scar, the lessened liability to relapse, and the avoidance of surgical measures."

The Lortet-Genoud Lupus Lamp.—In the summer of 1901 a great advance was made in the mechanics of the particular form of local photo-therapy which Finsen had previously made his own. By those who claimed that Finsen's method was the best means of treating lupus it was admitted that two grave drawbacks had been evident from the first: the length of time required for curative results, and the need of a current of seventy to eighty amperes—sufficient to light 160 incandescent sixteen candle-power reading lamps. Moreover, the device of a condenser to secure the needed maximum amount of light and of a filter to eliminate the heat rays led in practice to a serious loss of the chemical rays and reduced the dosage they were employed to increase. With the costly Finsen tube apparatus the field of treatment was an area less than the size of a silver quarter of a dollar, or an English shilling. Efforts were therefore made to dispense with the device which required a seven-fold increase of current to overcome its interference with the active dosage, but to do this it was necessary to protect the patient from the heat, as before, and to use the chemical rays so near their origin that dispersion was not allowed to take place. The first lupus lamp to attain these ends deserves specific mention here, though others soon followed and surpassed it. Certainly it was no small achievement to reduce at one step the Finsen current from eighty to twelve amperes; to reduce the exposure-time from an hour to fifteen or even only ten minutes; and to bring down the total duration of treatment from many months to a few months. With the above was also a much less primary cost and a very much lessened cost of operation, the results in their entirety being that a method impossible outside a wealthy institution having financial support was made feasible for any hospital, or practice in a private office. The first apparatus which thus simplified the technic was the lupus lamp of Lortet and Genoud, made by Souel of Lyons. It is shown in the accompanying illustrations in this chapter. (Plates 201, 202, 203.)

The direct current arc takes twelve to fifteen amperes at from fifty-five to sixty-five volts, regulated by a rheostat. The carbons are adjusted at an acute angle, the positive carbon being eight millimetres in diameter and the negative twelve millimetres. They last four or five sittings and are easily replaced. The arc is regulated by a system of screws. The essential novelty is a metallic besin, double-walled, with sides seven millimetres apart and a round hole in the centre of both bottoms twenty-five millimetres across, these holes being stopped with obturators which contain in their centre a plane lens of quartz. Through this rather remarkable device flows a current of cold water so that the double basin with the quartz "eye" screens the heat from the patient, lets all the chemical rays pass through, acts as a compressor, and by its close application makes the concentrating lens unnecessary. The whole apparatus is mounted on a heavy base which permits movements and adjustments in all directions. As will be seen in the illustration this apparatus brings the tissues close up to the crater of light instead of carrying the rays two feet to reach the patient, and this clinical revolution in method was the decisive advance over previous lamps.

Technic with the Lortet-Genoud Lupus Lamp.—Commence treatment at an outer margin of the diseased surface to prevent further extension. If there is suppuration employ other treatment to stop it before commencing the light. Also first remove crusts by a tepid boric solution, or other suitable means. If scaliness is present to hinder the passage of light-rays apply a little essence of cloves, which makes the epidermis transparent. When these obstacles of suppuration, crusts, and scales have been removed and the part is ready for the application of photo-therapy sterilize it carefully. If it is near the eyes protect them by a bandage. If it is upon the nose stuff a tampon of cotton into the nostril, and if the lips or cheek are involved also use an internal pad of cotton to diminish the pain of external pressure during treatment.

After making these preparations place the patient in a sitting or recumbent position in proper relation to the apparatus. Pose the patient so as to secure convenience and avoid discomfort. The compressors are made in three sizes—one and one-half, two, and three centimetres in diameter. A choice is important in treatment. The whole surface of the lens of the compressor must be in actual contact with the tissues to protect them from the heat rays and the circulation of water through the basin, which constitutes at once the heat-screen and the means of pressing the capillaries empty of blood for the penetration of the chemical rays into the lesion must be free from air bubbles and unimpeded. If air bubbles appear on the lens expel them

PLATE 197.—One of Finsen's cases before and after treatment.

Plate 198.—One of Finsen's cases before and after treatment.

Plate 199.—One of Finsen's cases before and after treatment.

PLATE 200.—One of Finsen's cases before and after treatment. The preceding series of Finsen plates are here inserted for the valuable purposes of comparison. When improved apparatus makes photo-therapy the ready resource of every physician with high efficiency at low cost, and a technic with as little trouble as the expert now finds the X-rays, it will be of great interest to turn to the work of pioneers and compare their apparatus and results. These pictured records are taken from transient copies of medical journals and collected here in permanent form to encourage and instruct those who have read of Finsen's work without realizing what it was like. These plates show what it was like in 1901, after the development of the two prolific years of experience—1899-1900. At the date of this writing, early in 1902, a revolution is taking place in the mechanics of photo-therapy, and what is pictured to-day will soon be historical and obsolete.

by freeing the outflow before beginning the application. Also sterilize the compressor for each treatment.

For plane large surfaces, such as the cheek, select the largest lens. For irregular or small surfaces, such as the chin, ear, nose, and near the eye, select the medium or small lens, which will give the best contact. For parts of such shape that complete contact with any compressor is impossible then cover the lesion with a layer of tin-foil cut to fit and with a hole in its centre corresponding to the portion of the area that can be properly compressed by such part of the lens as will make close contact. Then apply the compressor over this window in the foil so that the rays will pass at right-angles with the centre of the lens.

Next fix the carbons in their carriers so that their ends nearly meet. Attach the upper carbon to the positive pole and the negative to the lower. Draw back the mirror far enough to prevent contact with the arc. Now turn on the current with all the rheostat resistance in circuit, and adjust the carbons and rheostat so as to give an even light of maximum intensity. Then cut off the current, adjust the apparatus to the level and position suited to the patient, place the lesion in relation to the screen, and apply the compressor to the part in firm, absolute contact so that the axis of the rays will be perpendicular to the plane of the surface treated. Maintain steady and sufficient pressure on the tissues during the application to render them anæmic as desired. (See Plates 201, 202, 203.)

All is now ready for the therapeutic exposure. Move forward the luminous point of the arc till it is two centimetres from the compressor, with the crater of the positive carbon slightly above and the centre of light exactly in the path of the axis passing through the lens to the tissues. The rays now fall on the tissues only about four centimetres from their source and fulfil the conditions required for the greatest therapeutic energy. Make the first exposures eight or ten minutes only. If more intense reaction is needed after testing the patient's susceptibility, increase the séance to fifteen minutes, using care and judgment as to the duration. During the séance watch the patient and the arc; keep the carbons adjusted as they consume, and keep the compressor firmly applied. At the end of exposure-time cut out the current, release the patient, cover the lesion with boric vaseline on a small square of boric lint, and during the following days maintain an aseptic condition to avoid suppuration.

In certain cases the reaction is very intense; therefore limit the length of the sittings, and separate them at sufficiently long intervals to avoid excessive action. In experiments made to compare the energy of this *closely applied* light with the more remotely applied light of Finsen's tube apparatus it was found that "the newer method reduced sensitized paper in two or three seconds while the older method required six seconds; an exposure to the forearm of three minutes produced an intense erythema followed by desquamation, and ten to fifteen minutes suffices to produce the reaction necessary for cure." The fact that the older method of getting the light-rays to the tissues took daily exposures of a full hour was due to the far greater distance of the lesion from the source of light more than to any other feature of the technic. Light diminishes according to the law of inverse squares and an arc two feet removed is quite a different thing from an arc at four centimetres.

The Foveau-Trouvé Lamp.—Leaving the original Finsen-tube apparatus, which required State aid or great fees to pay the cost of treatment, still further in the rear is a little lamp which claims priority over the Lortet-Genoud device and superiority in operating features. All we can here say of it is stated in a communication from the designer:

"Priority in the matter of simplifying the arc-light for lupus therapy belongs to me. My apparatus was shown in action at the Institute of France on December 24, 1900; that is to say before the lupus lamp of MM. Lortet and Genoud, which was described at the Académie des Sciences de Paris on March 4, 1901. The Lortet-Genoud apparatus is patented, while besides this drawback it is also more costly, more complicated, and less effective, than the radiator of chemical rays devised by M. Trouvé and myself. This has not been patented and is therefore at the service of all instrument-makers.

"I beg attention to one further point, viz.: that the usefulness of our invention extends also to tuberculous lung disease, a fact that I was the first to point out. In proof of the claim of priority I refer to my communications to the Institute de France, December 24, 1900; to the Académie Royale de Médecine de Belgique, December 29, 1900, and March 30, 1901; to the Académie de Médecine de Paris, April 16, 1901; and to the Société de Dermatologie et de la Syphilis de Paris, May, 1901. Instead of an arc-lamp requiring eighty or even sixty amperes of current, a special installation of lenses, a large circulation of cold water, a cupro-ammoniacal solution, costly sittings of long duration for the treatment of an area of one or two centimetres, our apparatus consists of an incandescent lamp with special carbons, requiring from five to eight amperes, placed in the focus of a parabolic reflector with a conical concentration, a small circulation of water and two plates of quartz forming a compressor; or, an arc-lamp answers even better." (See Plates 204.)

It will thus be seen that the cost of photo-therapeutic apparatus for Finsen methods has already been reduced from the early sum of nearly $1,000 for installation, and which was still half that sum till these later lamps arrived, is now in a fair way to attain the moderate price and operating simplicity for which the majority wait. Without much question the early expensive forms of apparatus are obsolete; the therapeutic principles survive.

Progress in Photo-therapy Lamps.—We will now consider for a moment the wide departures from the common commercial incandescent lamp which promise shortly to provide new intensities of therapeutic rays with convenient dosability, simple apparatus, and small cost. To at all appreciate the future of photo-therapy the medical mind must entirely ignore the reading light or commercial illumination and consider what can be done with selected rays. The following from electrical journals illustrate:

"The subject of electric lighting has not been exhausted by any means. A new beginning has been made by the recent introduction of a modification of the old kaolin light, whereby the mixture of oxides as a light-emitting element has served to produce a glow which is more brilliant than an incandescent light, yet not so dazzling as an arc. Meanwhile the Nernst lamp looms up on the horizon. Intermediary in intensity between incandescent and arc-lamps the new light promises to be a most important factor as soon as it is put commercially on the market. The quality of the light and its complete steadiness recommend it, while its high efficiency, approaching that of an arc-lamp, make it especially valuable for many uses."

We can now contrast a new type of arc lamp with the "Actinolite" and Finsen's tube apparatus, which consume heavy currents of sixty to eighty amperes each, and which are therefore not suited to office practice. It possesses the other great advantage of low heat-rays with intense chemical-rays so that no cooling device is required on the skin of the patient, a fact which simplifies the technic.

"Dr. Bang, the well-known Danish physician, has constructed a new electric lamp which is likely to prove of great importance, even outside the field for which he has intended it. In the ordinary arc lamp the carbons are heated to some 3,000 degrees, but Dr. Bang has succeeded in avoiding this high temperature by making the carbons hollow and letting a strong current of water run through them. The effect is very singular. Almost the whole of the energy of the electric current is removed to the light arc between the two electrodes, while the latter themselves *remain so cool that one can touch them with one's fingers while the lamp is burning.* In addition to this the carbons are consumed so slowly that the usual automatic adjustment can be dispensed with. In science the new lamp will no doubt be invaluable, says *Engineering; its cold light is able to kill bacteria in one-eighteenth of the time required with the light of the ordinary* *arc-lamps.* The electrodes can be made from different substances, according to the use for which the lamp is intended. For medicinal purposes, carbon, silver, and certain kinds of iron appear preferable. Metallic electrodes have been used for several years by doctors, but they have had many drawbacks; they gave a great heat, the metal melted, etc., and it was necessary to place the patient at a comparatively great distance from the lamp. All these objections have been overcome—or, rather, entirely removed—in Dr. Bang's lamp, which is very small and handy, and in *which consumption of electricity is exceedingly small.*" (ELECTRICAL REVIEW, January 4, 1902.)

The manager of the Laboratory in Finsen's Light Institute (Dr. Bang) writes the following notice of his new lamp:

"No former lamp has been so constructed as to produce the coldest light with the richest generation of ultra-violet rays, but the writer has now succeeded in making such a lamp by using metals of suitable spectral properties, as, for instance, iron, the spectrum of which is well known to be very rich in the desired rays. The use of these metals as electrodes without melting them has been made possible by cooling them with water, either by making them hollow and letting a current flow through, or by placing larger lamps in water in a specially constructed vessel. In this simple way a light of unexpected properties is obtained. While with carbons the greatest quantity of light comes from the points of the incandescent carbons, especially from the crater of the positive carbon, the arrangement in question gives a real arc-light, as it is almost exclusively the arc between the electrodes that emits radiation. The effect of the cooling is therefore not only prevention of the fusing of the electrodes, but also that the formation of the crater is much reduced; the energy developed thus passes to the arc, and the arc-rays are produced rather than the electrode rays.

"The bactericidal power of these rays is such as has not hitherto been realized. While the usual arc-lamp of twenty-five amperes and fifty-five volts at sixty-six centimetres distance and under the most favorable conditions kills Staphylococcus pyogenes aureus in four and one-half minutes, the latter is killed by the lamp described, with iron electrodes and equal current power and other conditions, in somewhat less than four seconds, which shows a bactericidal power of sixty times that of the usual arc-light. Similar results are shown regarding the irritant effects on the skin of these cold rays. Five minutes' radiation at one metre distance from the lamp is sufficient to produce a well-marked light erythema of the whole face, which lasts for several days.

"For local treatment the writer has constructed quite a small lamp, which, including various adjuncts, is not much bigger than a tablespoon. This lamp is placed upon the skin *in toto*, as the light arc is so cool that it can be placed at one to one and one-half centimetres from the skin. More than 150 trials, upon sound as well as upon lupus skin, have shown that a lamp of five amperes and forty volts gives in five minutes (generally in three minutes) over a sur-

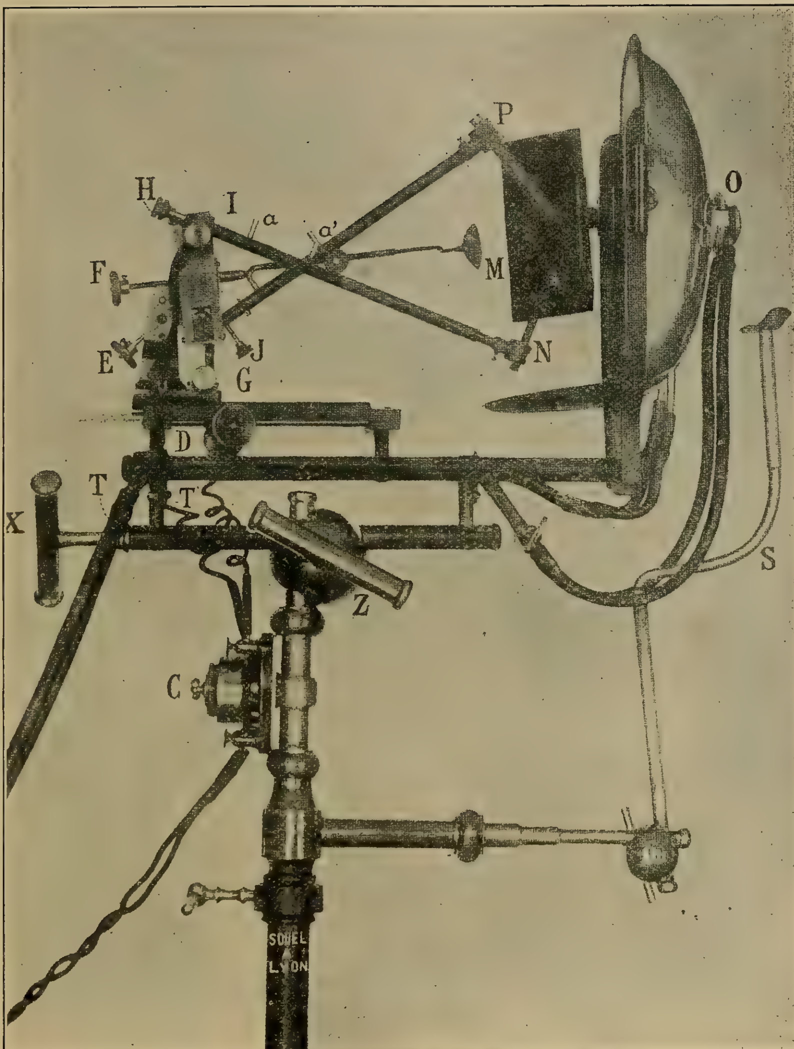


PLATE 201.—The Lupus Lamp of Lortet and Genoud. Explanation of lettered figure. a a are two small levers. By pressure on them the operator removes old carbons and replaces new; D advances or draws back the arc; E is a screw which raises or lowers the arc; F is a screw which regulates the separation of the carbons of the arc; G gives a lateral movement to the arc; H advances or draws back the negative carbon; J gives lateral movement to the positive carbon; M is a small mirror behind the arc; T T are two tubes to connect with the water-pipe; X is the handle which turns the lamp as desired when the set-screw Z has been loosened.

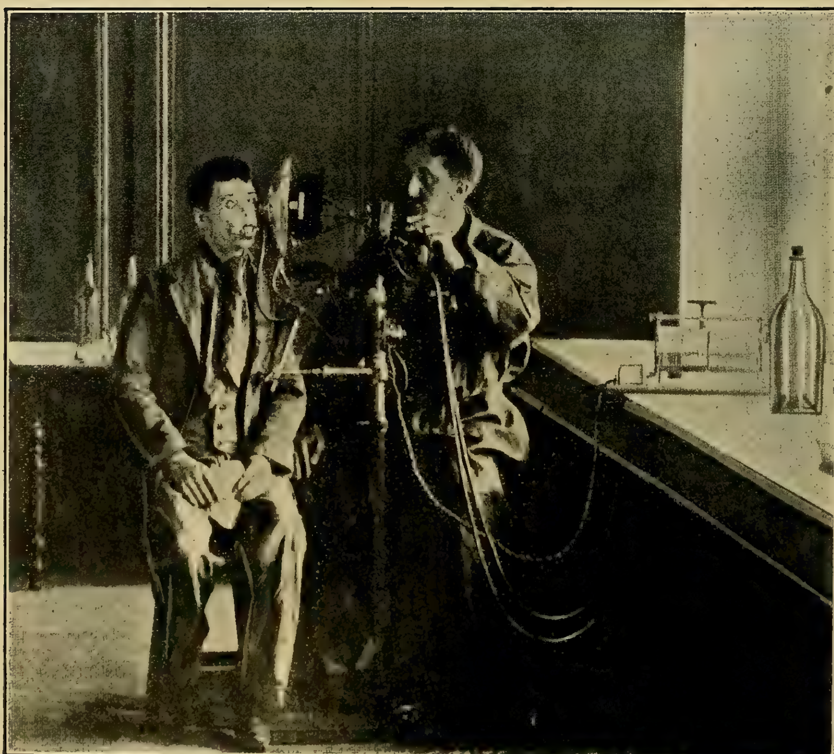


PLATE 202.—This copy of a French Plate shows the clinical method of employing the L.-G. lupus lamp, with the patient in position, and close contact made by the compressor on the diseased area.

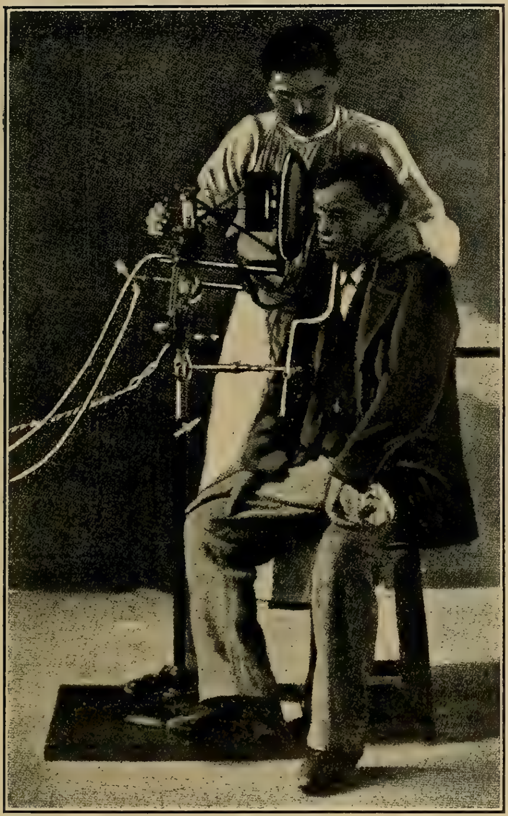
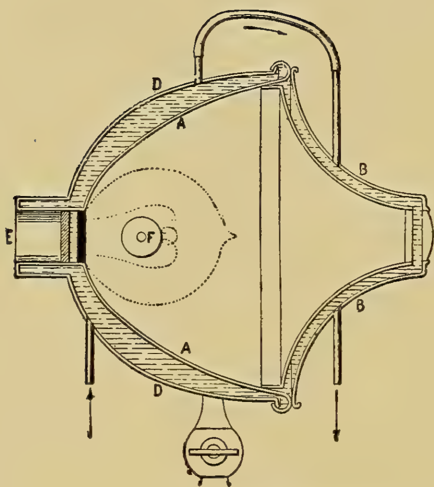


PLATE 203.—This copy also shows how the patient is placed in position for treatment with the L.-G. lupus lamp. While these plates are copies of inferior prints, yet they illustrate the method better than nothing. Fine original photographs to represent this apparatus were expected, but though ordered some months ago, the lamp was so long delayed in shipment, transit, and custom-house, that we go to press without as yet seeing the first apparatus of this kind brought to this country.



Apparatus seen in section.

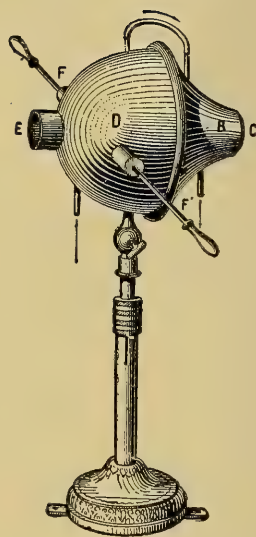


FIG. 1.—A, Parabolic mirror; B, prolongation of cone of concentration; C, quartz chamber (compressor) for the utilisation of the entire chemical radiator; D, inner cooling covering; E, opening for the utilisation of both direct and other rays, for inspection and regulation of the arc; FF, carbons which can be regulated at will; G, adjustable support for the apparatus.

PLATE 204.—The Foveau-Trouve Lamp.

face of ten square centimetres light reaction of the same strength as from the usual apparatus of sixty amperes and fifty volts in five and a quarter hours. In other words, to obtain this effect with the old apparatus 33,500 kilowatt seconds were necessary, which treated four patients, therefore 3,375 kilowatt seconds per patient; whereas with the new lamp only sixty kilowatt seconds, or one fifty-sixth of the energy formerly consumed. As is quite natural, the effect is higher if a stronger current is used, but as the effect of the usual lamps are in practice nearly proportional to the amperes, it would appear that the bactericidal power of the new lamp is proportional to the whole quantity of energy, or to the number of watts (five to ten amperes and thirty to fifty volts). The most suitable current seems to me to be eight amperes and forty volts. *As the light of this lamp is very powerful no concentration is necessary. In consequence of this, and as no automatic regulation is necessary, the lamp is very cheap to construct, and it can be used on any ordinary installation for incandescent lamps.*

"As I have found that unauthorized makers have distributed low quality products under the name of 'Finsen's apparatus,' and quacks have made 'improvements' upon them, I have applied for patents for this lamp in its different forms, as technical uses may be found for it. The applications are dated from July 29th to August 17, 1901."

In most marked contrast with this cold light is the special filament invented by the English electrical engineer, Dowsing, which can be made so rich in red (heat) rays that it is put on the market as a substitute for gas-radiators in the heating of small rooms. With the adjuncts of reflectors and couch a series of Dowsing lamps, or rather, radiant-heat tubes, form a therapeutic apparatus which we will describe in a later chapter of this section. Still another remarkable variation of special ray effects was described by Mr. Cooper Hewitt before the American Society of Mechanical Engineers, in New York, January 4, 1902. His light in vacuum tubes with mercury gas instead of filament has no heat (red) rays, and with chemical action requires no cooling device for the patient. We, therefore, see that invention tends to a direct production of selected rays for therapeutic uses instead of filtering out with great difficulty selected rays from a common source. This is a marked advance.

"Mr. Hewitt's lamp consists simply of a glass tube, with a bulb at one end, into which he introduces the gas generated from mercury. The tubes, when filled, are connected with the ordinary electric power in any building and the current turned on. The gas acts as the conductor and as soon as the switch is turned, the tube is flooded with light. Four of these tubes were placed at regular intervals around the gallery of the auditorium last night and one was hung from the ceiling. The incandescent lights were also turned on, and the light from these looked like jets of uncertain yellow flame, as compared with the light in Mr. Hewitt's lamps. The lamps attached to the gallery gave a light equal to that of about 200 candles, while the one which hung from the ceiling and the one over the entrance to the house seemed to have about twice as much power. Mr. Hewitt says that he can produce his light at about one-eighth the cost of the incandescent lamps and about one-third the cost of arc-lamps and of gas-lamps. The lamps were used last night chiefly to illustrate Mr. Hewitt's paper and to show to the members of the institute what progress he had made in his experiments. In the course of his paper he said:

" 'The mercury gas lamps exhibited to-night are operated on the standard Edison 118-volt direct-current circuit installed in this building; lamps of this class consume amounts of current varying from one to six amperes, and the efficiency is approximately one-half watt per spherical candle-power. Under better conditions as high an efficiency as one-fourth watt per spherical candle-power has been obtained, determined by careful and accurate measurements. I have made lamps with diameter of bore less than one-eighth of an inch and as large as three inches, and from less than three inches in length up to over ten feet, giving from less than ten candles up to fully 3,000. Lamps of very small bores give more trouble in manufacture and operation than those of moderate size. Lamps of innumerable shapes and dimensions have been constructed and great variation of candle-power for various diameters obtained. There appears no reason why lamps may not be made of any size required and of any desired candle-power per inch within wide limits, the only limitation appearing being that imposed by softening of the glass when too many candle-power per inch are produced. *It is possible to predetermine with almost absolute exactness the voltage, current consumption, and candle-power of a lamp when the manufacture is perfect.*

" 'The light produced by pure mercury gas comprises orange-yellow, lemon-yellow, green, blue, blue-violet, and violet. For some purposes the lack of red in the spectrum is objectionable, but for many uses it is a positive advantage.

" '*It should be noticed that this light has very great penetrating power, and seems to be effective through greater distances than an equivalent amount of measured candle-power from the ordinary incandescent lamp.* This may be due to the fact that the waves of the red light are less penetrating than those waves which are present in the mercury light, and hence the least valuable portion of the spectrum having such illuminating effects is omitted, and the energy is practically expended in the more useful portions of the spectrum. When it is considered that this light, when obtained with mercury gas, has an efficiency at least *eight times as great* as that obtained by the ordinary incandescent lamp, it will be appreciated that it has its use in places where lack of the red is not important, for the economy of operation will much more than compensate for the somewhat unnatural color given to illuminated objects.' "

Through the courtesy of the inventor the author has been able to see this blue-light tube and to observe its spectrum. The spectrum certainly presents the appearance of great richness in the field beyond the blue. There is little heat on touching the tube when a moderate current is used, and there is apparently almost no radiation of heat beyond the tube. For a number of years laboratory work has been directed to completing this lamp in commercial form, and its entire range of action is being subjected to scientific investigation. It is in competent hands. It is known that its rays are exceedingly strong in bactericidal power, that it is simple, practical, and cheap, and the chief delay in offering it to physicians appears to be the business detail of the formation of a company to manufacture and sell it. It requires practically no installation; is almost as simple as screwing a lamp in a socket and switching in the current. The cost will be so reasonable that it may be fairly compared with that of this book. What this means to the general medical profession, if all expectations are realized, can hardly be estimated. On the other side—non-medical illumination—there still remains some modification to perfect the light, but it is hoped that by the beginning of 1903 it will be ready for public sale and use.

Sun Cases.—Here, in New York, a colleague recently told the author that one of his patients had quickly cured himself of an eczema on the hands by using a reading glass and the sun. In our section on X-ray lupus therapy a similar case is cited. There are probably many that do not come to our attention; but in the shining land of Southern California the method has free scope. To show what can be done with simple apparatus a physician writes in May, 1901, of his personal experience with "home-made" photo-therapy:

"For his sun method Finsen uses a lens eight inches in diameter, fitted into a band of metal about three inches wide and closed on the opposite side by a piece of plain glass. The chamber between these glasses is filled with blue water. This cools the fierce heat of the focussed light and lets only the chemical rays through. His patients take 100, or 200, or more treatments. I must claim some advantages for my own treatment and that of our fellow practitioners here, for we secure the same results, viz.: a cure with a minimum scar-tissue, and do it in a month with five or ten treatments instead of requiring over a year of almost daily sittings an hour long. The apparatus we employ costs as follows:

"A good sun-glass four and one-half inches in diameter.	$2 00
"Smoked glasses	50

"Chloroform q. s.	$0 25
"A metal punch	1 00
"Piece of leather for shield	05

"A total of $3.80. My own cases have been but twenty, yet my results have been entirely satisfactory to myself and patients, except one in which I used the Finsen method for some months and exhausted my patience and that of my patient, so that we both decided to call a halt, and, under my ordinary method, matters were brought to a favorable issue at once. The sun-glass is efficient in removing small moles and warts, in increasing the growth of the hair, in hastening the cure of eczema. Under either local (or, if necessary, general) anæsthesia it is efficient in the total destruction of lupus, epithelial cancer, and other growths of the skin. It is not to be compared with the knife, yet is at times superior to it.

"For the reason that the chemical action of the sun's rays penetrates deeper than caustic action is does work that the cautery and caustics cannot do. Its use should be acquired by every physician. It is exceedingly simple, yet requires some experience and care when dealing with facial blemishes where scar-tissue is dreaded.

"In the application protect the surrounding healthy skin by a leather shield in which cut a hole with the punch or a knife to exactly fit the margins of the diseased part—as in the lead "masks" used in X-ray treatment. In operating near the eye or nerve tracts additional precautions should be taken. Wear a pair of smoked glasses during this treatment of a patient to protect your own eyes from the intense brilliancy of the focus point, but wear them well down on the nose so that you can glance over the top from time to time and thus judge of the effect produced. Do not strive to do too much at one séance. Proceed cautiously, letting the patient return several times rather than burn so deeply as to leave an unfortunate scar."

CHAPTER XLV

PHOTO-THERAPY: PROJECTION ARC-LIGHTS AND ARC-LAMP CABINETS

Treatment of Tuberculosis. The Profound Action of Chemical Rays upon Tuberculosis. Ichthyosis Hystrix. Local Anæsthesia by Blue Electric Light Rays. The Arc-Light Cabinet. Notes on Actions and Effects.

In contrast with the high-intensity local applications of exclusive chemical rays we find the large arc-light used for more general purposes and in two distinct forms of apparatus. One of these projects the rays in the manner of a "search light" but with medical modifications, and the other puts two or four lesser arcs in a cabinet. Both forms of apparatus are shown in our Instruction Plates. To best understand the physiology and therapeutics of any one *light* apparatus this section on photo-therapy must be studied as a whole, for we cannot repeat every detail in each chapter. Physicians have met many such references as the following, which appeared in the *Medical News*, January 4, 1902. Few have the slightest idea how such treatment is carried out:

"**Artificial Light in the Treatment of Tuberculosis.**—During the past few years considerable attention has been devoted in some quarters to the treatment of pulmonary tuberculosis and various other tuberculous lesions by the means of intense artificial light. A serious drawback to this treatment has been the expense of the apparatus necessary for its fulfilment and the great difficulty in regulating the dosage necessary for individual cases. F. de Cournielles (Comptes Société de Biologie, November 22, 1901) employs the voltaic arc for this purpose. The source of light is placed very near the patient, the heat-rays being removed by a special apparatus designed for this purpose. In this manner one obtains with a voltaic arc of five to twelve amperes effects equal to those obtained by the employment of eighty amperes in other apparatus. A convex mirror concentrates the rays upon the desired region. This method gives a minimum amount of light and a maximum effect therefrom. Many cases of various tuberculous lesions have been successfully treated by this method, and its employment in all tuberculous conditions as a routine procedure is strongly urged."

The technic of such treatment with a projection arc-lamp is clearly indicated in the series of our Instruction Plates which shows the apparatus and patients under treatment. Referring readers to the Plates for illustration we will now present a report of clinical results. The first citation, it will be noted, refers to cases treated with a heavy current (fifty amperes), and is a sample of several reports which lack of space compels us to omit. The second is an example of cases treated with a much newer lamp taking but a quarter of the current and therefore more practical for ordinary medical use.

Among special mentions of the treatment of pulmonary tuberculosis by concentrated light-rays we find the following in the *Philadelphia Medical Journal*, September 21, 1901:

"That I might test the light-treatment, I purchased a fifty-ampere electric lamp with a twenty-inch condensing lens and had this arranged with an adjuster so that at a distance of fifteen feet the light could be concentrated on a surface an inch in diameter if it should be desired. With this concentration the heat is so great that it fractured a strip of one-fourth-inch plate-glass two inches in width at two feet distance and a strip of one-eighth-inch blue-glass of the same width at six feet distance. In using this powerful lamp a screen made of strips of blue glass is interposed between the patient and the lamp to cut out some of the heat-rays. The chest of the patient is bared and the light concentrated to a circle from fifteen to twenty inches in diameter according to the tolerance of the patient. The exposures vary from half an hour to an hour and are given daily.

"The first effect of the light is a diminution of cough and temperature within forty-eight hours. In most cases the temperature is down nearly to normal within the first week of treatment. I am accustomed to judge somewhat of the improvement by the gain in weight; this is taken the day of the first exposure, and subsequently every two weeks. In every case the amount of expectoration is perceptibly diminished and the number of bacteria to the field very much diminished within the first week of treatment. This indicates a reduced tax on the system, as the reduction of the number of bacilli to the field and the smaller quantity of expectoration makes a smaller army of microbes to be fed at the expense of the patient's system. Several patients who on beginning treatment walked a block with difficulty at the end of two weeks could walk a mile. The beneficial effect on appetite was always marked from the very first treatment. The cessation of the cough necessarily permitted better rest at night. It is remarkable with what rapidity symptoms are ameliorated under the influence of the concentrated rays of light.

"No. 1. H. B. B., aged thirty-three years, born in Connecticut. Trained Nurse. Came to me November 17, 1900. Menstruation regular, urine normal. In her mother's family, grandfather, two brothers and four sisters have died of pulmonary tuberculosis. Her mother is a picture of health and has always been well. No member of father's family has had any tubercular disease. In July, 1900, while on duty at the Seaside Home, she found herself growing weak, and her duties fatigued her greatly. She had noticed a morning cough for a year past, but it did not alarm her. By August the cough became annoying and there was increased expectoration. This alarmed her and she consulted a relative who is a physician and he diagnosed tubercular infection. Sputum was first examined October 5th, and found to contain bacilli in 'considerable numbers.' She was then taking creosote ♏ xxxx t. d. in capsules. Tr. Ferri Chloridi ♏ x t. d. Liq. Potas. Arsen. ♏ viii every other day, and Russell's Emulsion ʒ ii t. d.

"November 20th, light-treatment was instituted. Medication was continued with the exception of the iron and Russell's emulsion, Turk's emulsion of cod-liver oil in half-ounce doses was substituted at the suggestion of Dr. Reynolds. She was examined by Dr. Reynolds and myself. A cavity was detected in the apex of the right lung, but very small in size. Her pulse was rapid and weak. Skin soft and flabby. Eyes dull and heavy. Whole bearing indicated debility and malaise. November 21st sputum was examined by Dr. Craig and found to contain bacilli of tuberculosis. December 20th he found little if any change. January, February, March, and April, 1901, found them in gradually decreasing numbers. His May examination showed a few bacilli. April 23d, May 1st, May 18th, June 9th, and July 16th examined by Dr. Willis S. Cummings, my assistant, and 'no bacilli' found. On June 12th and 19th Professor Van Cott made careful examinations and could not find any tubercle bacilli and congratulated the patient on the result.

"The patient's normal weight previous to August, 1900, was 120 pounds. Then she found that she had lost six pounds. On November 20th she weighed 114 pounds. She continued to gain until February, 1901, when her weight was 119½ pounds, one-half pound less than normal. Her temperature had never gone above 100°, but after the institution of treatment it began to fall and by March 1, 1901, became normal. The cough was promptly mitigated, and expectoration decreased to such an extent that it was often difficult to get a specimen for examination. Physical examination from time to time by Drs. Reynolds, Cummings, and myself indicated a gradual but steady improvement in the condition of the lung. In April Dr. Reynolds, after examining the lung, pronounced it practically healed. May 12th Professor A. Jacobi, who was visiting me, kindly consented to examine Miss B. and stated that 'while there was evidence of degeneration having taken place, the process had evidently stopped.'

"The light-treatment began with half-hour exposures daily (except Sunday) on November 20, 1900, and continued until June 15,

1901. Light treatment and creosote were discontinued at that date. July 16th her weight was 119 pounds, cough had ceased, no bacilli in sputum, cavity apparently healed. The affection in this case has been stamped out and the patient cured of the results of this invasion of microbes. (See Plates 205 to 209.)

"No. 3. G. G. C., aged thirty-seven years. Express Clerk. Nativity, New York. Married. Contracted cold in December, 1899. Health continued to decline and tuberculosis was diagnosed. He had his sputum examined in May, 1900, but no bacilli were found. On June 1st he had another examination made and the bacilli were present. In spite of treatment, which seems to have been intelligent and skilful, he continued to decline in health. A cavity developed first in one lung and then in the other. In the fall it was thought best for him to go South and he went to Texas. The climate did not benefit him. On the contrary he lost ground steadily till the middle of December, 1900, when he came home to die. His physician referred him to me on his return home. It was with great effort apparently that he came to my office on January 1, 1901. He was greatly emaciated; there were good-sized cavities in both lungs. His pulse was feeble and rapid. Temperature running to 103½° every evening. Cough distressing, expectoration free. Sputum contained large quantities of bacilli. In fact his condition was such that I was not anxious to place him under treatment. But at the urgent solicitation of Dr. B. I took him under treatment.

"His first visit to my laboratory was accomplished with difficulty, although he had only one block to walk from the cars, which passed within three or four doors of his house, and it was only a ride of twelve blocks. His medication was Turk's emulsion of cod-liver oil, liquid peptonoids with creosote, and Fowler's solution. His light-treatment was daily exposures of one hour each from January 2, 1901, to June 1st. His improvement was rapid and remarkable. At the end of the first week he walked from his house to my office without fatigue, the cough was greatly mitigated; sputum decreased in quantity; temperature not above 101°; appetite greatly improved; night sweats decreasing. January 1st his weight was 131 pounds; January 14th his weight was 134½ pounds, showing a gain of three and one-half pounds in two weeks; 30th, his weight was 137 pounds, a gain of two and one-half pounds in the second two weeks, or six pounds in a month. April 3d his weight was 138 pounds, and has remained about that figure. By June 1st he was walking five or six miles a day. The sputum showed no bacilli. His lungs were cicatrizing, and he felt perfectly well. He procured an out-door position about the race-tracks, and treatment was suspended.

"This case is remarkable for the great and rapid improvement from the very start. I have treated ten cases in all. In every case cough, expectoration, temperature, and sudorosis have been relieved within the first few days. The appetite also has rapidly improved. While the period of experiment has been less than a year, the success

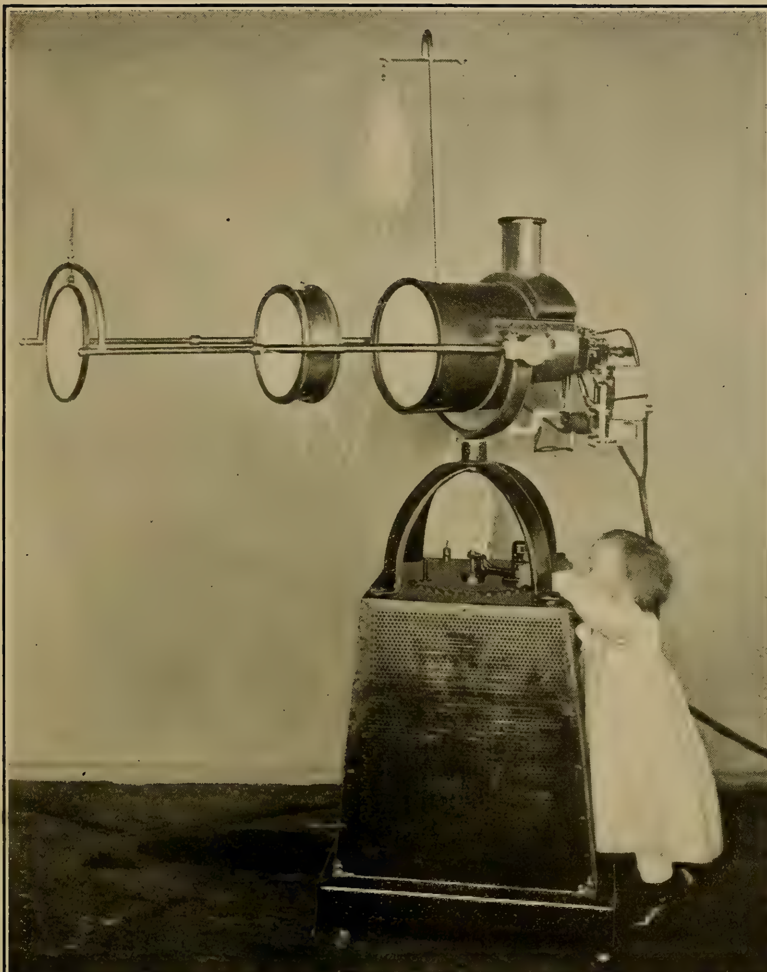


PLATE 205.—The series of ten Instruction Plates next following illustrate some of the uses of the new projection arc-lamp called the "Actinolite." It is made in three sizes, and uses currents from 25 up to 100 amperes. The child who ran to the rheostat to play with the switch just as the photographer snapped his camera gives a fair idea of the proportions of the medium 60 ampere apparatus.

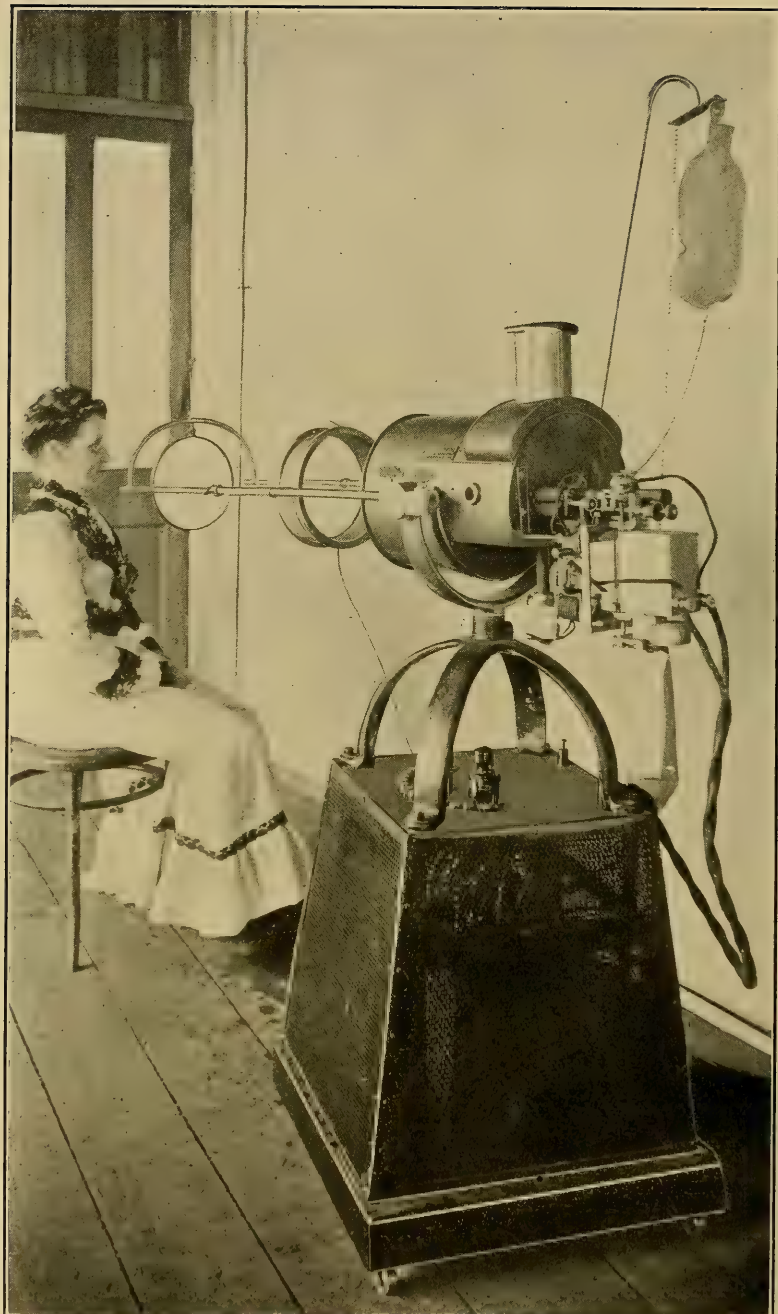


PLATE 206.—Showing adjustment to focus chemical rays on small area of cheek. Patient wears spectacles to protect eyes from glare. The water-bags keep a continuous flow of cold water through the filter seen just in front of the lamp-hood. The concentration lens near patient's face adjusts on sliding arms to the required distance.

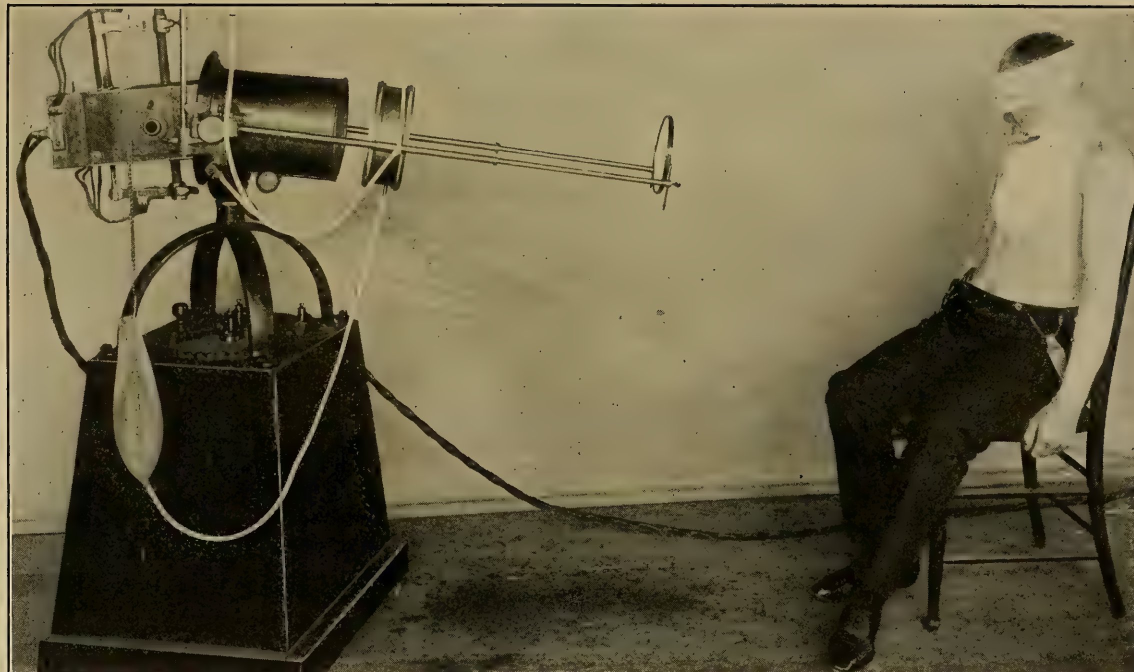


Plate 207.—At this distance the lens is directing light rays over the area seen on the patient's chest. This represents an application to affected portion of the chest in tuberculosis.

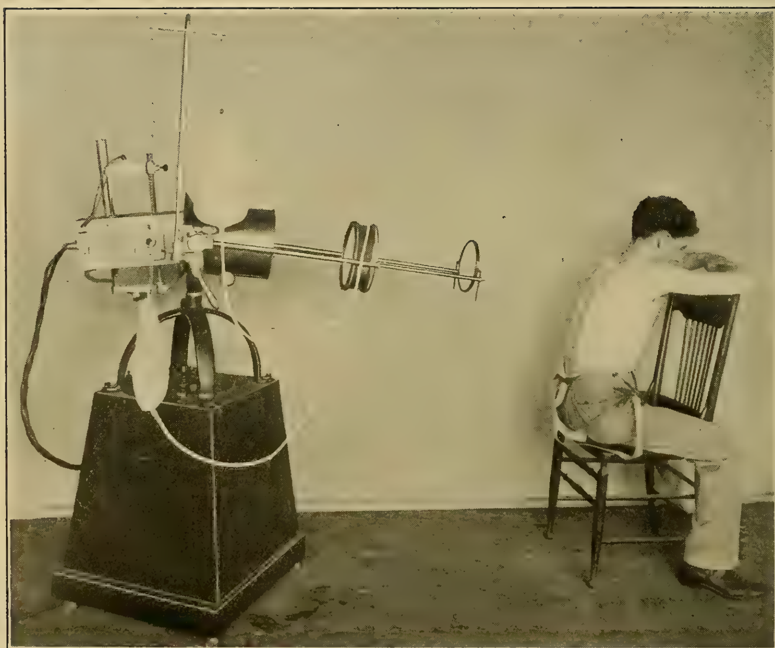


Plate 208.—Showing a tuberculous patient seated with rays directed to back. By sitting patient nearer the lens the radiation is made more intense.

has been sufficient to warrant a continuance of the treatment. It seems to me that we are pursuing a plan of treatment that promises much in the future. I would add a word of caution. The patients should not be exposed to cold without very careful protection for some hours after taking treatment, as the pores are open. The sudden cooling of the skin after prolonged exposure to heat will overtax the kidneys and possibly produce congestion in them.

"I would advise careful examination of urine in every case where treatment is being given. The treatment could be better carried on in a sanatorium. It is hoped that this paper may induce a number of the profession to try this method that its place may be determined as a therapeutic measure." (HOPKINS.)

Under the caption, "The Profound Action of Chemical Rays upon Tuberculosis," we find the following summary of de Courmelles's experience:

"The violet and ultra-violet rays act, in common with static electricity, high-frequency, and X-rays, to produce certain favorable effects in both external and internal manifestations of tuberculosis. In separating the chemical-rays from the arc-light by means of a current of cold water and a quartz lens there may be produced with a low current (twelve amperes at eighty volts) sufficient rays to be effective in lupus vulgaris, lupus erythematosis, various dermatoses, and (what is a new fact) in pulmonary tuberculosis. External reaction inflammation is not necessary to demonstrate the penetration. A case of lupus with cutaneous and osseous lesions of twelve years' duration, with cough and a slight souffle at the left apex, was submitted in the Hospital of Saint Louis to the influence of the rays, and after five sittings of ten minutes each the souffle disappeared. (September, 1901.) Since then various patients have been treated, and, notwithstanding the absence of heat, have all experienced an immediate sense of well-being followed by diminution of the cough and improvement in the stethoscopic signs. These facts deserve to be pointed out with a view to their being confirmed or disproved, or at least made generally known." (See also page 486.)

Lest the new reader in these fields of physical therapeutics should think that fancy played a large part in the claims of men who report much greater benefits to tuberculous patients than routine medical training leads the practitioner to expect, it is well to say here that neither novelty nor extravagance exists in these claims. On pages 482-5 of my Manual of Static Electricity in X-Ray and Therapeutic Uses, we find that both cancers and consumption were benefited proportionately as much in 1790 by the feeble electric currents then used as they are being benefited in 1902 by the more powerful currents now used. All along the century scores of physicians have been treating and benefiting these cases; some more than others because of greater skill and better apparatus, *but all demonstrating the fact that in high-potential electric discharges the medical world has long had the most effective weapon known against the diseases for which X-rays and light-rays have now seemed to be new remedies.* In Chapter XXX of my Static book, written in February, 1897, may be read methods of treatment and results in thoracic conditions, including consumption, that surpass anything done with the newer rays and technics. Yet most of the medical world calmly ignores the great boon of electricity in tuberculosis and goes on its way seeking serums and specifics or exploiting some flash-in-the-pan new "cure," while practitioners have only to take the resources always offered them by electricity and benefit these patients beyond any claims yet made. Personally the author can vouch for the fact that with larger currents and the better teachings of experience he can far surpass the results he described in 1897. As X-rays, light-rays, high-frequency effects, and static currents are all very closely related electrical discharges their actions can be easily studied without mystery or clinical doubts.

Ichthyosis Hystrix Treated by the Electric Arc-Light.—Dr. G. W. Goler writes upon the case of a boy whose arms presented dirty brown scales, thicker on the anterior surface and thickly beset with protuberances one-eighth of an inch in height, which looked like cracked flat warts of dirty-brown color and gave to the touch the sensation of a horseradish grater. After anointing with lanolin, the light from a twenty-ampere lamp was projected for twenty minutes daily upon the parts through two eight-inch plano-convex lenses mounted in pairs. By the third day the skin had lost its warty appearance, and at the end of seven days the skin was soft and normal. Subsequent application of the light was made to the legs, and after twenty exposures of about thirty minutes each there was complete recovery, which has persisted for three months.

Local Anæsthesia by Blue Light-Rays.—The following communication will interest a great many who can put it to test and prove the facts for themselves. The reliability of the statement is vouched for by the circumstance that the writer is the Senior Medical Officer of the Imperial Bodyguard Cavalry Regiment of Russia:

"To-day scarcely any one doubts the energetic therapeutic action of blue electric-light. The undoubted superiority which belongs to blue electric-light depends upon its action on the vasomotor nerves. Cold blue light is more active at a certain distance than in close proximity. Certain effects of blue light are the reverse of those of white

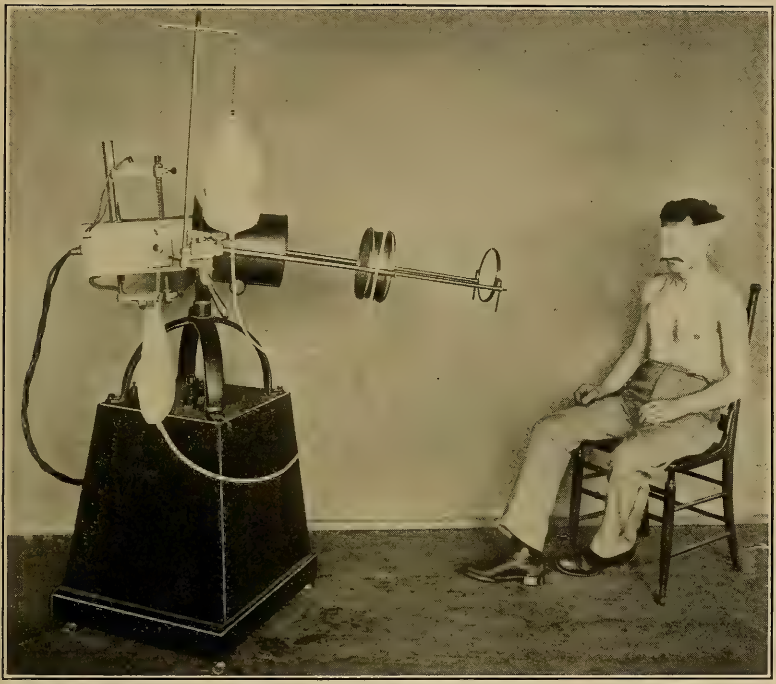


PLATE 209.—The same patient turned to direct rays on anterior surface in tuberculosis.

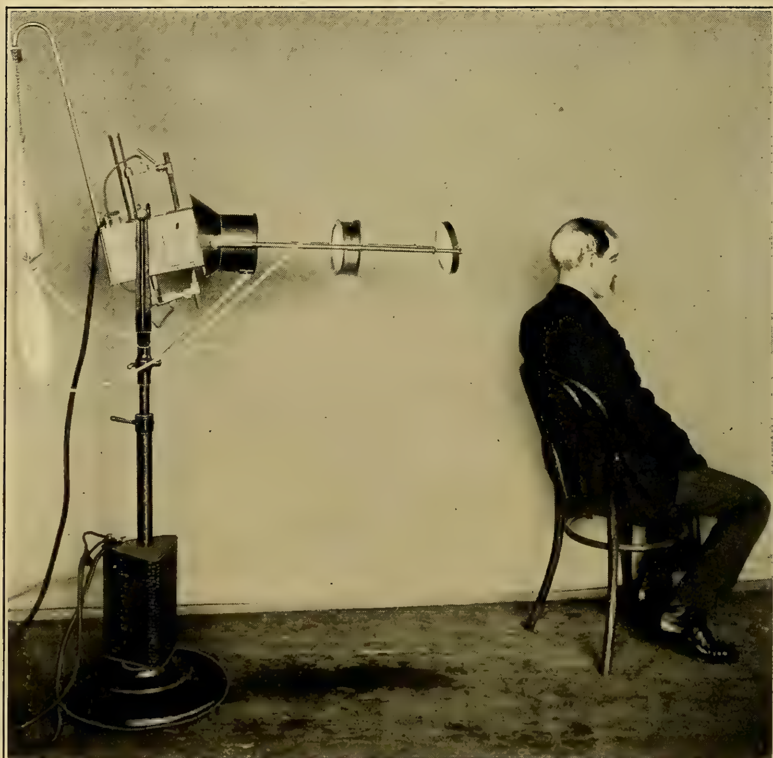


PLATE 210.—Showing the light-rays focussed upon a half of the scalp in parasitic disease. The current is on and the effect shown in the plate is exactly that of the light during the exposure without any retouching.

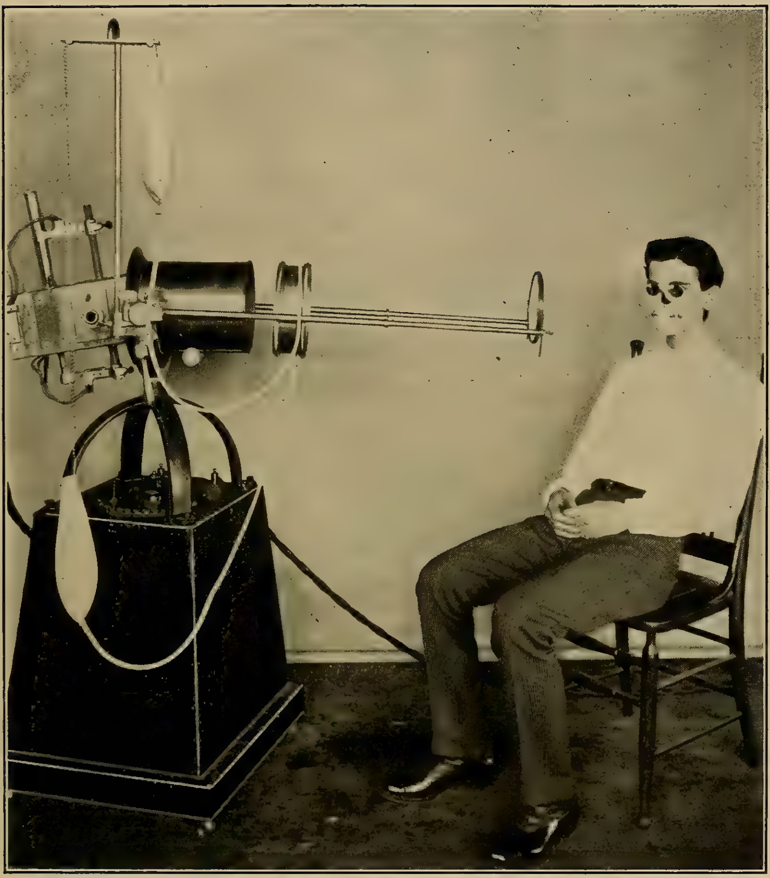


PLATE 211.—Showing rays focussed on end of nose and upper lip in lupus case. Patient is wearing dark glasses to protect eyes. No attempt at compression is made. For local applications this lamp is less efficient than the L. and G. lupus lamp for the reason that it acts on the tissues only at a very long distance from the source of light. It also uses four times the current.

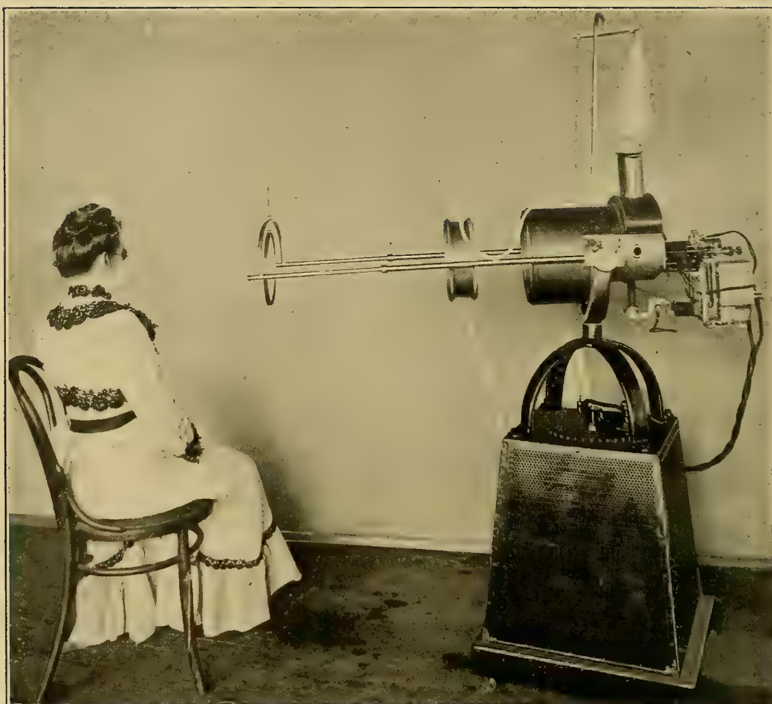


PLATE 212.—Showing a side view of lamp focussed on small area of face. As an experiment in attaining high candle-power with heavy currents this lamp was designed more for general treatment than for small lesions. It is probable that it will be improved in many ways.

light. For instance, a granulating surface will become anæmic under blue light and hyperæmic under white light.

"*The degree of pain-relieving power possessed by blue electric-light is far greater than I had hitherto supposed.* Although I had often been astonished at the alleviation brought about so quickly by the blue electric-light in acute pleurisies, still I had only used it for making a tender spot tolerant to investigation, but now my experience has shown that far stronger claims may be made for its action in this respect. *We now resort to the application of these rays instead of cocainization to render painless incisions and stitching of wounds, and the blue electric-rays not only cause a more complete anæsthesia, but powerfully promote healing from the beginning.* As examples I may relate two cases:

"1. Mr. X., Secretary of a foreign embassy, cut his finger with a piece of glass. The cut was on the outer side of the third finger and about three centimetres (more than an inch) long. After a ten-minutes' radiation with blue light from a small lamp of fifty candle-power, two stitches were made without pain. Healing commenced at once and was complete in four days.

"2. A soldier of the Bodyguard Cavalry Regiment cut the dorsal surface of his left thumb, the wound being three centimetres in length. After cleansing and a ten-minute radiation with blue light three stitches were introduced and the patient felt no pain. He chatted the whole time with those present and described the sensation as if 'a soft cotton ball was pressed on to the wound.' Healing by first intention was complete by the third day. These two cases place beyond doubt the fact that stitches may be introduced and removed without pain under the influence of blue electric-light." (Dr. Minin.)

The Arc-Light Cabinet.—The arc-light bath cabinet is an entirely different apparatus from the incandescent lamp bath cabinet and has a materially different therapeutic range. It provides a general exposure of the nude surface of the entire body to the nutritional or alterative action of either whole or filtered light associated with *moderate* heat. By connecting brush electrodes within the cabinet to a high potential coil or Static machine an ozone spray can be discharged during any portion or all of a bath séance in the treatment of pulmonary cases. I have seen two cabinets equipped for ozone sprays, and it is a very simple matter to add the feature to any cabinet when desired.

The particular arc-light cabinet shown in this section is new. It is made in sections so that it can be set up or taken apart with little trouble, and when in use rolls easily on castors and can be moved to any part of a room. The "bed" has a mattress covered with a germ-proof and fire-proof material, and the walls are white enamel. The entire inside can be washed with antiseptic solutions. The exterior is oak. The door is in panels so that any desired section can be opened or closed at will. Convenient to the head of the couch is a glass cuspidor to receive expectoration. It can be removed and cleansed at will. The light is furnished by two arc-lamps of either ten or fifteen amperes, as may be selected by the operator. The adjustment of the carbons is automatic, and "protectors" keep sparks from flying during treatment. A rheostat controls the regulation of the light and a *ventilating* device affords regulation of the degree of heat, which is registered outside the cabinet by a thermometer placed in view of the operator. A sliding panel fitted with blue glass enables the operator to inspect the interior when desired, and to communicate with the patient. The lamps are four feet above the recumbent patient and the light may be used as white, whole light, or it may be filtered through blue media for the more exclusive action of the chemical rays. The main objects of the cabinet are the treatment of tuberculosis, diseases of the respiratory tract, and general skin diseases—conditions which it is assumed that combined light, heat, and ozone can favorably affect. In these cases adjunct treatment must not be neglected, as no one agent can meet all indications.

The Instruction Plates 215 to 219 will make clear the uses of what is essentially an isolated compartment of the Light-Room of Finsen, described in another place. We need not dwell on its physiological possibilities or therapeutic advantages, as these are part of the whole subject of this section. It will be sufficient to cite the most recent remarks of an American physician who claims a clinical experience of now eight years with the treatment of many patients in an arc-light cabinet: *

"It is only necessary to keep in mind the condition of patients for whom *a general arc-light bath* is indicated to appreciate how essential it is that the *entire body* be exposed to the action of the light, and this, with a minimum of discomfort and without danger of chill. No better reason need exist than the well-being of the patient to lead us to select the cabinet as a means of exposing the entire body to the radiant energy of light, for it is self-warming and superior to an open room in all cool seasons of the year. That arc-light therapy produces some physiologic effect by reason of its heat-rays cannot be gainsaid in view of the well-established action of heat upon nutrition, and in the class of cases for which the cabinet treatment is indicated the moderate warmth is extremely grateful as well as beneficial. Nor should the value of the ozone generated be lost sight of. Its physiologic action is to increase the number of red blood-corpuscles, the hæmoglobin, the urea, and to establish nutritive changes, and, therefore, in the arc-light bath the benefit is not the result of actinic rays alone.

* Condensed from the Journal of Physical Therapeutics.

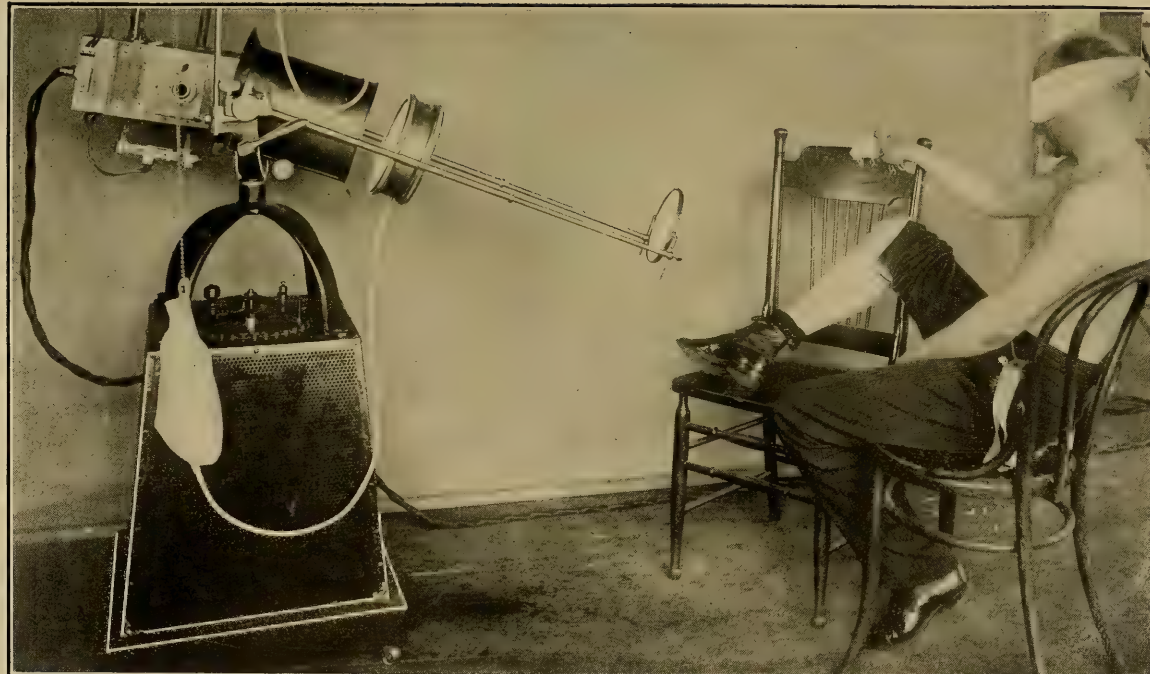


PLATE 213.—Showing lamp adjusted to direct rays on lesion of the leg. Patient sitting.

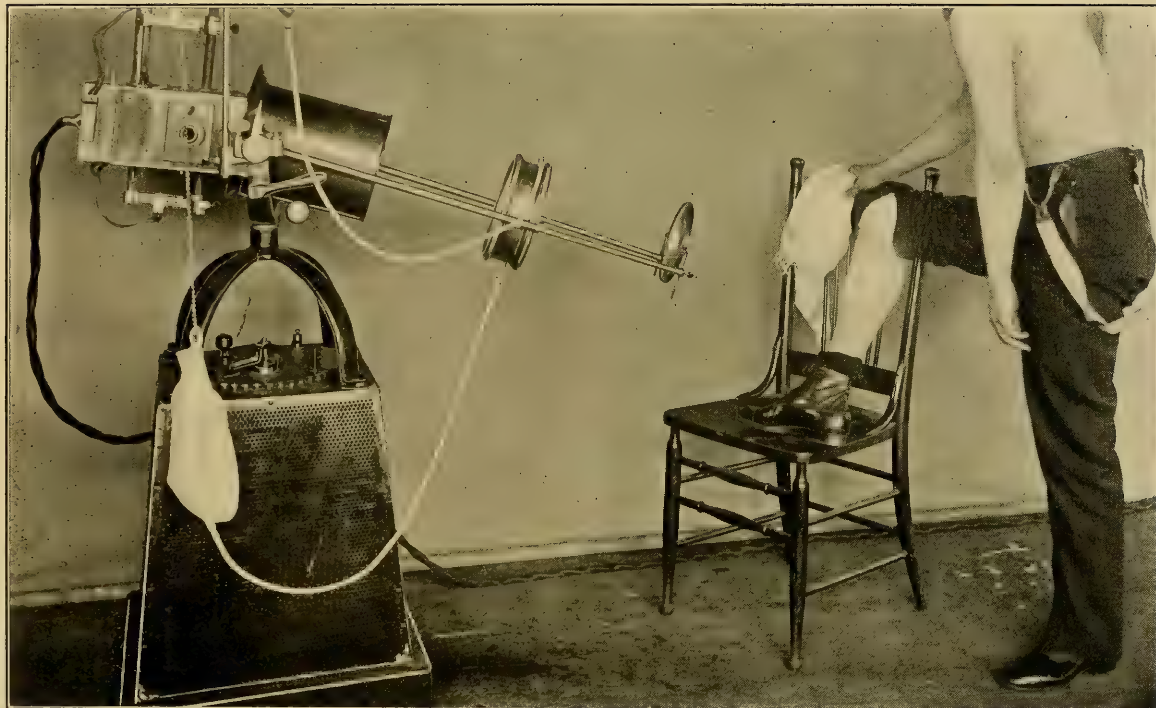


Plate 214.—Treatment of ulcer on leg with patient standing. By the use of high currents this lamp aimed at reducing exposure time to a few minutes, but in its present form requires further improvement. It is here shown chiefly to illustrate the early phases of the development of photo-therapy as fully as possible in this work. It affords excellent comparison for study.

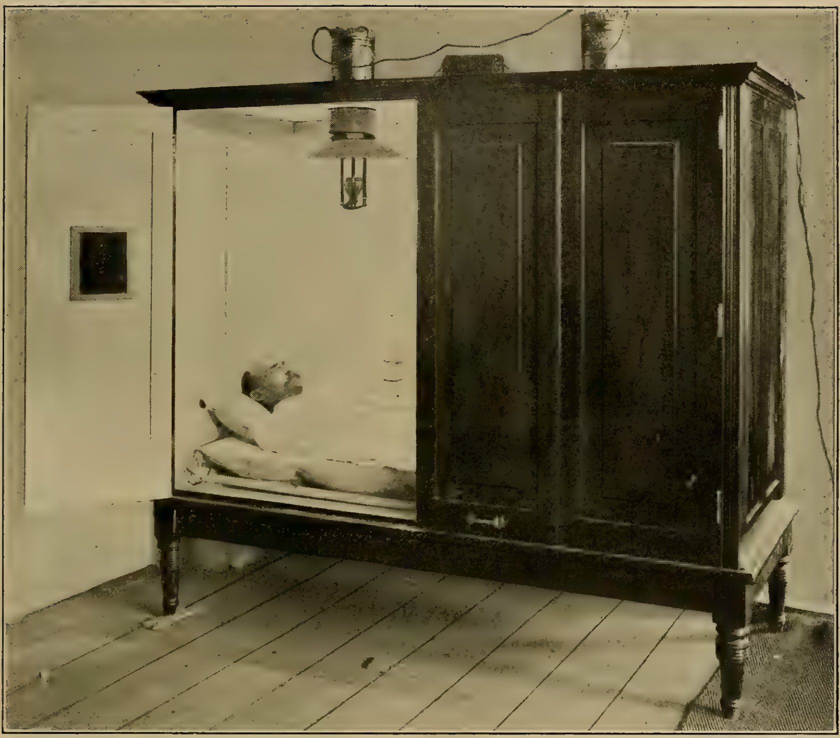


PLATE 215.—The five Instruction Plates immediately following illustrate a new Arc-Light Cabinet having two 15 Ampere lamps, with special reference to the general administration of the chief chemical rays with only a small amount of the heat rays. Especially designed to treat pulmonary tuberculosis and general skin diseases. Also for general tonic alterative effects. See text for full description and clinical information. This plate shows the patient on the asbestos couch covered with sheet, and last doors of cabinet ready to be closed. The blue glass observation-window seen in the open door gives the operator a view of patient during treatment. When the cabinet is closed direct patient to remove sheet to allow rays to reach entire body without hindrance. The cabinet only attains a comfortable warmth. It is not a "radiant heat" apparatus.

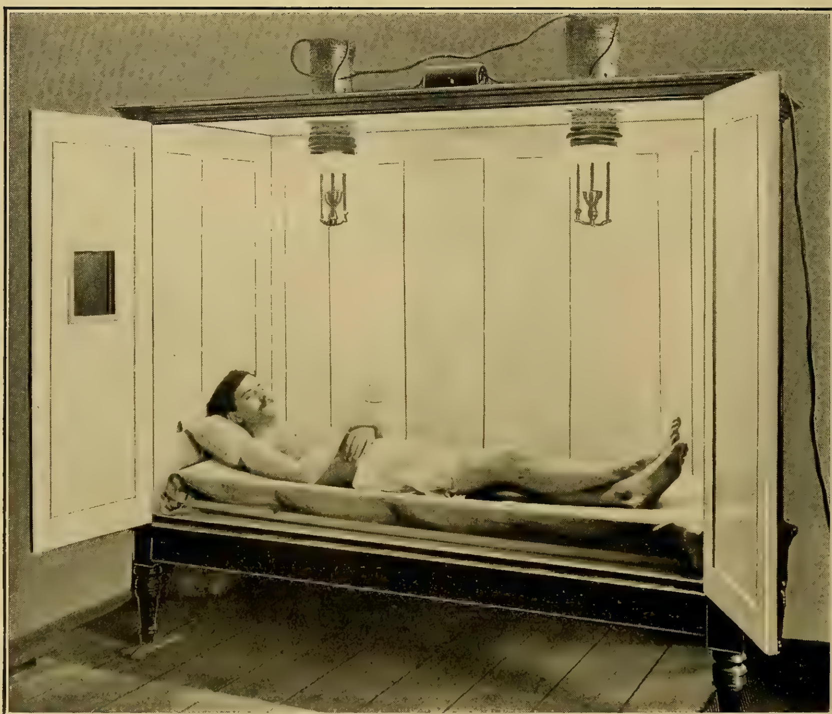


PLATE 216.—This Plate shows the Cabinet with front open and both lamps in view. The small glass cuspidor near patient's head is for expectoration during treatment. Instruct patient to breathe deeply while in the cabinet.

Some action from the visible spectrum as well as from ozone must be considered.

"The effects noted from the clinical administration of electric arc-light baths in such a cabinet as is here described have included the establishment of circulatory changes with a uniform regulation of the heart's action—as shown by improved volume and slower rate of pulse—a temporary and slight rise of temperature, increased activity of the skin, improved respiration, fuller and slower and gradually increasing respiratory capacity, and diminished irritability of the mucous membranes and lessened discharge in tubercular, bronchial, and asthmatic patients and in catarrhal conditions of the nasal passages.

"There is an increased excretion of urea and CO_2, accompanied by an improvement in nutrition and function. Patients treated in the cabinet have uniformly presented an appearance of being rested and refreshed, and not infrequently they fall asleep during the administration. In diseases of the respiratory system a soothing effect upon the mucous membranes is always experienced, while, from the first bath the cough and expectoration diminish. This has been regularly noted in every case of pulmonary tuberculosis, but in advanced cases the relief has not been maintained. Every case of bronchitis has also had prompt relief from the cough and expectoration. In persons convalescing from acute bronchitis, broncho-pneumonia, and grippe, with constant harassing cough, inability to sleep, great physical weakness, lowered nerve-tone, etc., relief has been obtained from the first treatment, characterized after a few moments in the bath by fuller and freer respiration, lessening of the irritability of both nasal and bronchial mucous membrane with diminished cough and expectoration.

"Upon the conclusion of the treatment they have invariably presented an appearance of increased vitality which has been evidenced by improved respiration and pulse as well as by a sense of well-being which without exception they have themselves remarked upon. These improved conditions seem to point to something which acts directly upon the mucous membrane as a powerful oxidizing agent. Even in cases where the cough was incessant there has been complete relief during the twenty to forty minutes spent in the cabinet bath.

"From the well-known physiologic action of ozone it is felt that it is a vital factor in *general* applications of the electric arc-light for diseases of the respiratory passages. In profound anæmias, in the various manifestations of disturbed nutrition, in neuritis, rheumatism, and in such skin affections as acne, eczema, and psoriasis, the results are due to the chemical rays mainly. Their influence upon the capillary circulation initiates the circulatory and resultant nutritive changes, followed by the disappearance of the special manifestations of disease characterizing the individual case. That the same physiologic action takes place when the condition is one in which the respiratory passages are involved goes without saying, but the speedy relief obtained from difficult respiration and harassing cough would seem to point to an agent acting directly upon the mucous membrane rather than indirectly through its influence upon the peripheral circulation. It is unnecessary to recapitulate here the various pathologic conditions in which the arc-light bath is valuable. The therapeutic indications are as broad as those for sunlight and pure air."

Notes on Actions and Effect.—In writing of his photo-therapy Finsen contributed the following note on arc-light baths in October, 1900:

" For five years or more I have had a general form of light bath in mind to give an exposure of the whole body to the chemical rays of light. This idea I have carried out in practice, but have not published anything about it. . . . These chemical light-baths, such as I have suggested and carried out, are quite different from the electric light 'radiant heat' baths in their effects. They are cold as to temperature, they produce a very strong action of light on the skin of the highest value, and have an excitant action which needs further study. The dilatation of the capillaries and blood-vessels of the skin produced by light is not altogether an acute or rapid process, but is in reality of long duration. *The light treatment of the skin will result in dilatation of cutaneous vessels and determine a more active blood-supply thereto, which in its turn must be assumed to favorably influence nutrition and enable the skin the better to perform its functions.*

" For my *light baths* I sometimes employ the sun and sometimes the arc-light. In the sun-baths the patients promenade naked in a sunlit yard where everything is done to keep down the temperature in order to avoid sweating—by frequent sprinkling of the ground or by shower-baths on the skin to reduce its temperature. The effects are widely different from those of sun *sweat*-baths.

" My 'electric-light baths' consist of a circular room about forty feet across, with two immense arc-lamps of 100 amperes each placed in the centre about six feet from the floor. Radiating partitions from the centre of the room divide it into several compartments with beds placed in an inclined position. On these beds entirely naked the patients rest. The temperature factor of the light is so low that the room must be artificially warmed for the comfort of the patients, yet the chemical action on the skin is as strong as powerful sunlight. It produces a pleasant sensation of slight prickling and warming on the skin. In some persons an exposure as short as ten minutes will produce a pronounced erythema, while others will have only a slight reddening after an hour's exposure. There is, therefore, a great difference in individual susceptibility to the action of chemical rays on the skin, and some care must be exercised in regulating the exposure-time."

The different degrees of effect of the three light baths (white incandescent, blue incandescent, and blue arc) upon the pulse and temperature of the same persons have been carefully studied by Dr. Bokemeyer. The tests were made at the same hour of each day under exactly similar conditions with all precautions to ensure scientific accu-

Plate 217.—Another view of the Arc-Light Cabinet showing patient exposed for general application of the rays to entire spine and back of body. He can turn to either front or dorsal position at any time the physician directs during treatment.

Plate 218.—Showing how two or more little children can be treated in the Cabinet at once. Remove the clothing and let them romp and play in the bath for fifteen minutes. There is no sensation save that of the comfortable warmth. No dark glasses are needed to shield the eyes, as a screen below the arc protects the patient from the glare.

PLATE 219.—This Plate shows the Arc-Light Bath Cabinet as it appears when closed with patient inside. The thermometer near the observation window records the temperature during treatment, and this usually reaches 95 to 100 degrees F. Each section of the front is removable, and on casters the apparatus can easily be rolled to any part of a room.

racy. Exposures were limited to the time required to raise the bath from an initial temperature of 77° F. to 144½° F.; and this was eighteen, twelve, and twenty minutes in the white, blue, and blue-arc tests. Omitting the extensive details and tables of these observations we find that the results show:

1. The White I. light raises both pulse and temperature to a much higher degree than either kind of light filtered through blue media. The increases were not proportional and varied in different individuals; ranging from twenty-five increased beats per minute and 3.30° F. to fifty-nine beats extra pulse rate with only 1.90° F. added to the temperature of the body. The whole white light excels in radiant-heat effects. The red-rays in whole light are the strongest exciters of the whole nervous system. Removing the red-rays by a blue filter we next note:

2. Under Blue I. light, pulse and temperature were influenced within a narrower range, and, though the bath heated to 144° F. in a third less time, the action was milder despite the rapid heating. Pulses were increased only from four to thirty-nine and body temperatures from 36° F. to 1.26° F. The blue filter therefore gives, at the same heat, a very different effect upon the pulse and temperature. Its use will be indicated when it is desired to produce quick perspiration without great excitement of the nerves.

3. The Blue Arc-light causes only small fluctuations to pulse and temperature. In some cases the pulse remained nearly normal. The highest increase was thirty-two. In some cases the temperature by the mouth remained normal while the greatest rise during an exposure was 72° F. This form of light is used for the chemical actions of blue-rays in larger quantities than the small candle-power of incandescent lamps yield, and when the sudorific effects are of the least importance.

With whole white light a strong irritation of the skin is often felt by the patient, while in the blue arc-bath the sensations are extremely mild. Yet in these tests the arc-light exposure was twenty minutes.

Perspiration generally commenced when the heat of the bath reached 3.60° to 5.40° F. above the body, but with *whole* light often began before blood-heat was reached. In one case it commenced at 83.75° F. This occurs from the fact that radiant-heat radiations act direct upon the sudorific nerves. When the red rays are filtered out by blue globes the sudorific effect becomes less for the same incandescent lamp and still less for the arc-light.

In studying the effect of the appearance of perspiration upon the heart and temperature it was found that it had a decided influence in preserving the equilibrium, and that the subjective well-being of the patient was never disturbed. Anguish, oppression, palpitation of the heart, and difficulty of breathing do not occur in connection with light baths under therapeutic regulation.

Bokemeyer also noted the difference in weight after each form of light bath. It varied from a half to a full pound only in the above tests, though the difference is generally one to one and one-half pounds when the white or blue incandescent baths are given their usual time, and temperature of 155° to 167° F. In the reported tests they were kept down to the average of the arc-light baths, which are seldom carried beyond 144.50° F. We will next take up the subject of light-rays from glowers which are enclosed in low-vacuum bulbs, and shall see that great variety is already entering into this form of therapeutic apparatus—as yet scarcely known by name to thousands in the medical profession.

CHAPTER XLVI

PHOTO-THERAPY: INCANDESCENT ELECTRIC-LIGHT CABINET BATHS

Distinctions in Character of Light-Baths. Flotsom. Physiological Actions of Mixed and Whole-Light Rays. Dr. Kellogg's Cabinet Apparatus. Technics of Treatment. Studies in Facts and Faults.

In the consideration of incandescent electric-light baths it must not be forgotten that these lamps are of small candle-power (the usual reading lamp is but sixteen candle-power), while therapeutic arc-lights have run from 20,000 up to more than 60,000 candle-power. Obviously the lesser *total* of rays must be proportionately less in chemical-rays and the ability of light to kill bacteria, to cause inflammation, to produce pigmentation of the skin, and, finally, its exciting action, are all bound up with the chemical rays; and to be therapeutically energetic they must not only be present, but must be richly abundant, concentrated, and brought close to the specially prepared part. Note that the conditions in the incandescent-light bath are the antithesis of this. The candle-power is small, the chemical rays are few and not concentrated, they are not brought very close to the tissues, and the general field of treatment is not rendered anæmic. Neither is the field of treatment a mere spot, as in the Finsen method, but is any region or all of the body save the head. It is not only important to keep this distinction clear in our study of this therapy, but we must also note that there are several classes of incandescent-light baths of quite different degrees of action.

1. The Kellogg (and German) bath cabinet, now very widely used in foreign sanitariums, and well known in this country but less used than abroad, which is a luminous "radiant-heat" bath, producing sweat and alterative actions without much raising the patient's temperature or that of the cabinet. Perspiration takes place with the patient in an atmosphere of about eighty-five to ninety-five degrees.

2. The newer "Radiant-heat" bath of Dowsing, which employs specially constructed electric lamps of the incandescent type, and which

raises the temperature of the cabinet and of the patient as much or more than the "Dry hot-air apparatus."

Therefore, do not let the terms "electric-light treatment," "electric-light bath," "radiant-heat bath," etc., confuse themselves in your mind. It is important to apply each to its proper use and to no other. Distinguishing terms would be:

1. Radiant-heat baths. (High temperature luminous-rays.)
2. Sudatory Light baths. (Inducing sweat at low temperatures; 85° to 95° F.)
3. Chemical Light baths. (Arc-lights with main heat-rays excluded.)

Before passing to the more scientific study of these rays it will be of interest to note a few of the ephemeral and waif-like mentions in current medical literature which do so little to inform the practitioner of what he needs to know, but which may here point the way to fuller knowledge in connection with the text. Floating through current medical literature we find considerable variety in scattered references to observed effects of red, blue, and white light. For the benefit of combined therapeutic suggestions we may note a sample of each:

"The *Lancet* in a recent number remarks that in our conscious superiority to our forefathers we have been used to look with contempt on their ways of treating cases of small-pox by means of red light in the form of red blinds, curtains and coverlets, but with our present knowledge of the chemical and physical action of the different rays of the spectrum and the influence of light and darkness on life's highest and lowest manifestations, we may have felt a suspicion that whatever the theory of the mediæval physician, their freaks may have had a scientific basis.

"In a late number of the *Zeitschrift für Krankepflige*, we find that it has been tried, and apparently with remarkable results, in the treatment of measles. A child eight years old was stricken with measles. On the second day he was brought under the influence of red light. In three hours the rash disappeared, the fever subsided, and the child was apparently well, wanting daylight to play in. The red blinds were removed and daylight admitted to the room, but in three hours thereafter the medical man was again summoned and found the rash and fever had returned and the child was weak and prostrate. The red light was again resumed, the rash again disappeared in a little over two hours as did the fever, this time permanently. In two more days the child was well in every respect.

"Strebel gives a somewhat lengthy account of his experience with light-baths, having apparently found them useful in any form of disease in which they were tried. He mentioned especially that they were valuable in kidney and heart-disease, in diabetes, and obesity. It had particularly good effects in arteriosclerosis and fatty heart."

"Minin achieved remarkable results by the use of electric light in the treatment of superficial wounds, burns, and a few cases of skin eruptions. The effect of electricity in these cases depends on the light and not the heat, inasmuch as the best results are obtained with the light at a considerable distance from the body. Blue light constricts the blood-vessels and produces marked anæsthesia, while white light has the opposite effect. The anæsthesia caused by blue light is as marked as that produced by cocain, and the author employed it successfully in minor surgery. Two cases are cited in which superficial wounds were sewed up under the influence of blue light of fifty candle-power, without the patient experiencing the least pain. Contusions due to falls were promptly cured by blue light. In one case, a burn of the first degree yielded to two applications of the blue light from a lamp of fifty candle-power, each sitting lasting ten minutes. In another case of injury to the mouth, throat, and œsophagus caused by the accidental ingestions of ammonia, several applications of the blue light accomplished a complete cure. The light was directed to the mucous membrane of the mouth and in front of the neck and chest. A case of rheumatic purpura was cured by the application of white light from a fifty candle-power lamp followed for a few minutes by blue light from a lamp of twenty-five candle-power. In another case of simple purpura five applications of the electric-light resulted in a cure, after other remedial agents failed. The treatment also exerted a beneficial effect on the general nutrition of the patient."

"Gerault of Paris recently had as a patient an employe of an electric machine factory, who had a severe case of chronic rheumatism. Upon being assigned to some special work in a room where the rays from a fifty candle-power incandescent lamp fell horizontally on him at close range he soon noticed a marked diminution of the pain and reported it to his physician, who had similar lamps placed in his office. Rheumatic and other cases so far treated have given excellent results."

Says Dr. Robinson: "In the field of dermatology the use of light as a therapeutic agent gives promise of great value. I have known a long-standing case of eczema universalis permanently cured by the sufferer exposing himself, nude, to an hour's sun-bath under a large window on all sunny days during July and August. All other conditions remained the same. All previous treatment had totally failed."

We will now begin the study of psysiological actions as a guide to therapeutics. Dr. Sibley of the N. W. London hospital gives us the following suggestive study in connection with radiant heat:

"I now propose to mention some facts relating to the addition of luminous rays to non-luminous heat. I am especially interested in experiments to determine which of the light-rays have the most penetrating therapeutic effects. A great many observations on this subject have been made on plants and the hæmoglobin of the animal cell has been compared to, and has many functional similarities with, the chlorophyll of the vegetable cell. There are therapeutic principles in these observations:

"A.—*General.*

"1. *Action of Rays of Different Refrangibility.*—The rays of different refrangibility which together constitute sunlight, and appear as variously colored bands in the spectrum, vary in their physiological action on the processes of plant life. Chemical changes, so far as they are in the main dependent on light, are produced chiefly or solely by rays of medium or low refrangibility (namely the red, orange, yellow, or green). This is the case, for instance, with the production of the green color of chlorophyll, the decomposition of carbon dioxide, and the formation of chlorophyll, starch, or sugar. On the other hand, the rays of high refrangibility (the blue or violet as well as the invisible ultra-violet rays) are the principal or the only ones which produce mechanical changes, so far as these are dependent on light. It is these rays which influence the rapidity of growth, alter the movements of the protoplasm, compel swarm spores to adopt a definite direction of their motion, and change the tension of the tissues of the mobile organs of many leaves, hence causing movements.

"2. *Action of Light of Different Intensities.*—That the action of light on plants varies with its intensity, as does temperature with its elevation, admits of no doubt, and is obvious in all physiological observations.

"3. *Penetration of the Rays of Light into the Plant.*—The rays of greatest refrangibility are in general almost entirely absorbed by the superficial layers of tissue, while the red light penetrates most deeply.

"B.—*Special.*—(1) *Chemical Action of Light on Plants.*

"(*a*) *Formation of Chlorophyll.*—All the visible parts of the solar spectrum have the power of turning the etiolated chlorophyll granules green, but the yellow rays and those nearest them on each side are the most powerful, and this is also the case with the exhalation of oxygen from cells containing chlorophyll.

"(*b*) *The Decomposition of Carbon Dioxide.*—The influence of light upon the evolution of oxygen is greater the more carbonic acid is contained in the air; only those rays which are visible have the power of decomposing carbonic dioxide, and those which appear brightest to the eye (the yellow rays) are alone as efficacious in this process as all the others put together.

"(*c*) *The Formation of Starch in Chlorophyll Granules.*—The formation of starch is a function of chlorophyll granules exposed to light, its absorption a function of chlorophyll granules not exposed to light. The formation of starch in chlorophyll granules depends on conditions which favor assimilation; and the principal feature of the

PLATE 221.—The Upright Electric-Light Bath. The general indications for this apparatus are the same as for the horizontal cabinet, and the application is the same, but persons suffering from cardiac lesions, and especially obese patients, are often more favorably treated in vertical positions.

PLATE 223.—The Horizontal Electric-Light Bath. This form of cabinet is most convenient for general purposes when sufficient floor-space can be commanded. From sixty to one hundred sixteen-candle power incandescent lamps are required for the various degrees of dosage. The cabinet is freely ventilated, and the temperature of the air within it may not be greater than that of the room in which it is placed.

process, the evolution of oxygen, proceeds vigorously in light consisting of red, orange, yellow, and to a certain extent of green rays; while the more strongly refrangible half of the spectrum, consisting of green, blue, violet, and ultra-violet rays, has only a very slight effect.

"(2) *Mechanical Action of Light on Plants.*

"(*d*) Without discussing the question, it may be briefly said that the influence of light on the movements of protoplasm varies according to the nature of the motion.

"(*e*) *Cell Division and Growth.*—Light retards growth; but it is only the rays of high refrangibility, the blue, violet, and ultra-violet, which act in this way.

"(*f*) *Action of Light on the Tension of the Tissue of the Organs of Leaves endowed with Motion.*—It is only the more refrangible rays that produce a paratonic effect, while the red rays are inert.

"These few remarks on the actions of the various light rays upon plant life would seem to open up a wide field for experiment and observation with regard to the treatment of diseases by different light-rays in addition to heat-rays. It is probable that as we learn more of the pathology of those conditions we are accustomed to treat we shall be able to decide beforehand what particular colored rays would be most serviceable to the treatment of any given disease. Apart from some general principle, if we desire a treatment which shall not tend to produce burning of the skin, but one which will penetrate into the tissues, we shall use the red-rays, and *vice versa.* As a matter of experience, I have found the heat produced by red-rays far more soothing and less irritating in its effect than using the whole of the rays of the visible spectrum together.

"With regard to the general effect of the luminous rays there is no doubt that the addition of luminous rays to ordinary non-luminous radiant heat produces an increased diaphoresis. Patients who do not sweat with non-luminous heat very quickly do so when some light rays are added, and this is often noticeable even at a lower temperature than had been previously tried."

From plants to human beings may seem a long stride to many, and some may think the above a mere laboratory study with no practical application, but in Cornell University and other experiment stations it has been demonstrated that the electric-light is a physiological alternate for darkness. One of the most complete and important researches ever made into the actions of general light-rays on human beings may be read in the classical paper of Dr. J. H. Kellogg, who has kindly furnished us the substance of his work for our instruction here. It is as follows:

"Siemens found that the plants exposed to ordinary daylight and six hours of electric-light in addition 'far surpassed the others in darkness of green and vigorous appearance generally.' Strawberries and other fruits were fully equal to those raised under ordinary conditions, and grapes were of stronger flavor than usual. Melons were remarkably large and aromatic, and bananas were pronounced by excellent judges to be 'unsurpassed in flavor.' Many of these experiments have been repeated in this country and with similar results. The most important experiments were those conducted at the Cornell University Agricultural Station in 1889-90. These results showed clearly—

"1. That the electric-light may be used under such conditions as to make it fairly comparable to sunlight in its power to promote protoplasmic activity.

"2. That the electric-light acts as a tonic to plants so that they are able to endure adverse conditions which otherwise would cause them to collapse.

"3. That the electric-light is a true vital stimulus, since the effect of its use at night, upon plants, is essentially the same as that of the longer day of the Arctics upon plants growing in that region.

"Although not fully acquainted with the facts above referred to when I first began the use of the electric-light bath, I had seen brief notices of these experiments, and thereby became interested in the subject from a therapeutic stand-point. For more than twenty years I have made use of the sun-bath as a therapeutic means, and twelve or thirteen years ago experimented with large convex lenses for the purpose of concentrating the sunlight, and thus intensifying its effects in the treatment of neuralgia, and spinal and other hyperæsthesias.

"Something more than four years ago I began experiments with single lights provided with reflectors, and soon after had constructed two cabinets, or small rooms, large enough to contain one person, with fifty to sixty incandescent lamps arranged in regular rows on the inside. Since that time I have made constant use of the electric-light emitted by the incandescent lamp, as a therapeutic means. Together with my colleagues I have employed the bath by this means nearly 10,000 times, and in a great variety of ailments, at the Battle Creek Sanitarium, and have largely used it as a substitute for the Turkish, Russian, vapor, and hot-air baths, all of which I had previously employed for many years. Finding it free from any of the objections to which the baths named are open, for numerous reasons, some of which I will point out subsequently in this paper, and also finding its effects extremely agreeable to patients, and remarkably efficacious in many stubborn cases which did not readily yield to other therapeutic agents, I have employed it much more frequently than I had previously made use of analogous means, and in a much wider range of cases.

"My earliest experiments in the use of the electric-light bath showed me that it was capable of producing very characteristic effects. This led me to undertake a series of physiologic experiments for the purpose of placing its therapeutic use upon a rational basis, and for the purpose of comparing the effects of the electric-light, Turkish, and Russian baths. Some of these experiments were made three years ago; others have been made more recently. The objects of the experiments were to determine the effects of the electric-light bath as compared with those of the Turkish and the Russian baths upon—

"1. CO_2 elimination.
"2. Urinary secretion.
"3. Perspiration.
"4. Surface and internal temperature.
"5. The number of blood corpuscles and the amount of hæmoglobin. The results of these experiments and the methods employed may be summarized as follows:

"1. *CO_2 Elimination.*—Three healthy young men were subjected to the influence of the incandescent electric-light or radiant-heat bath for five, ten, twenty, and thirty minutes respectively, the time being the same for each, and all other conditions being made as nearly alike as possible. The same young men were likewise subjected to the influence of the Turkish and the Russian baths for the same lengths of time, but on different days, care being taken to maintain a uniform dietary during the entire series of experiments, at the same hours of the day. The average per cent. of CO_2 obtained before the experiment, was 3.60. For the electric-light bath the average per cents obtained were as follows:

5 minutes	4.10	20 minutes	4.20
10 "	4.10	30 "	5.10 and 5.13

"In a repetition of the thirty-minute bath, the higher percentage of 5.13 was obtained. For the Turkish bath the average per cents obtained were:

5 minutes	4.03	10 minutes	4.07
30 minutes	4.01		

"For the Russian bath the per cent. was 3.96 for a bath of thirty minutes. The highest amount of CO_2 elimination was 4.29 litres, which was in the incandescent electric-light bath for thirty minutes. The temperature of the air in the baths was as follows:

"Electric-light bath, 28 to 36 degrees C. (85 to 97 degrees F.), or constantly below the temperature of the body; Russian bath, 38 degrees C. (100 degrees F.); Turkish bath, 55 degrees C. (131-155 degrees F.).

"2. *Urinary Secretion.*—The following table shows the average figures obtained for the three young men who were the subjects of experiment. The facts determined in relation to the urine were: the amount, the specific gravity, the acidity, the amount of urea, the amount of uric acid, the total chlorides expressed in terms of HCl, the phosphoric acid, and the total solids. The figures given were determined by accurate quantitative analysis of the whole amount secreted in twenty-four hours. The figures obtained in relation to the most important of these quantities were as follows:

Electric-light bath: urea	26.32	gms.
Total chlorides	5.25	"
Total solids	49.30	"
Turkish bath: urea	27.39	"
Total chlorides	6.91	"
Total solids	52.70	"
Russian bath: urea	29.56	"
Total chlorides	7.60	"
Total solids	55.14	"

"The figures obtained for the urine were the exact reverse of those obtained for the CO elimination. The diminished amount of urea, total chlorides, and total solids present in the urine during the twenty-four hours in which the subject was subjected to the electric-light bath, was evidently the result of increased elimination by the skin, showing that the electric-light bath is much more powerful than either the Turkish or the Russian bath as a means of stimulating vicarious eliminative work upon the part of the skin. The amount of perspiration induced by the incandescent electric-light bath was fully double that induced by the Turkish bath in the same length of time. The amount of perspiration induced by the Russian bath was less than that induced by the electric-light and the Turkish bath.

"3. *Perspiration.*—Two points were determined in reference to perspiration:

"(1.) The time required to induce perspiration.
"(2.) The temperature at which perspiration began.

"The averages were as follows:

"*Incandescent electric-light bath:* time required to induce perspiration, three minutes, thirty-two seconds. The average temperature at which perspiration appeared was 27.2 degrees C. (eighty-one degrees F.).

"*Turkish bath:* the time required to induce perspiration, five minutes, thirty-five seconds. Temperature of the bath, 53.6 degrees C. (128.5 degrees F.).

"*Russian bath:* the time required for perspiration, six minutes, forty-five seconds. Temperature, 101.8 degrees F.

"The above figures show very clearly the superior value of the electric-light bath as a means of stimulating cutaneous activity.

"4. *Surface and Internal Temperature.*—The influence of the bath upon surface and internal temperature is a matter of importance, since Bouchard has shown that the heat-regulating apparatus of the body is called into operation by a rise in the temperature of the blood equal to .40 degrees C. (.72 degrees F.). In experiments made in December, 1891, for the purpose of determining the effect of the bath upon surface and internal temperature, I obtained the following results in a comparative study of the effects of the electric bath and the Turkish bath upon surface and internal temperature:

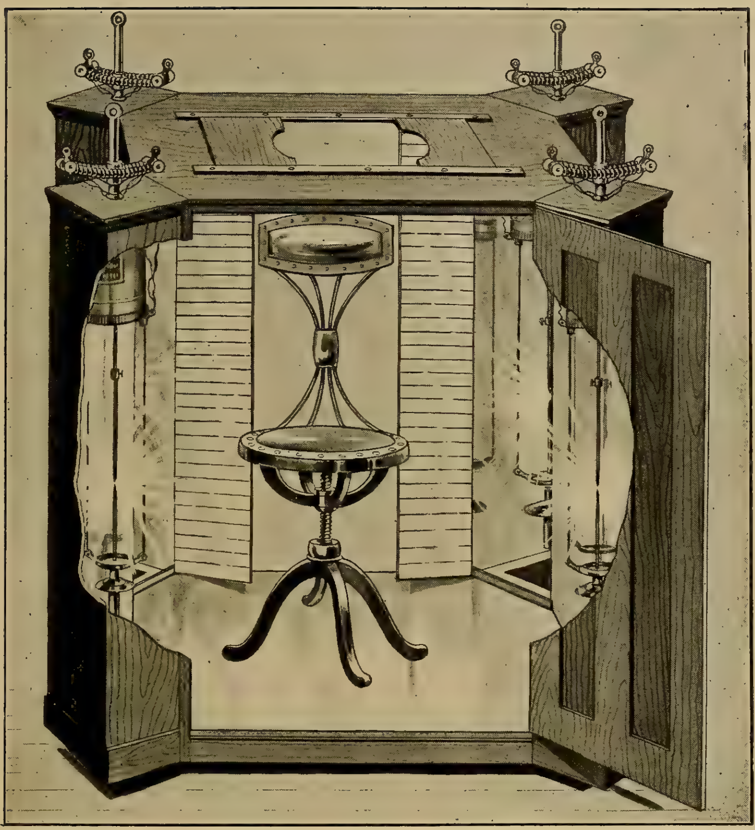


PLATE 225.—The Arc-Light Bath. This bath is rather imperfectly shown in this plate. It may be used either for the heating purposes of the calorific and luminous combined rays, or for the special effects of the chemical rays which influence the nervous system chiefly. When the latter are employed screens of cobalt glass are placed around each of the four arc-lights, situated one at each angle of the cabinet. When heating effects are desired, the mixed rays are employed without screens. The general indications for after-treatment with the arc-light bath do not differ essentially from those described for the incandescent electric-light bath.

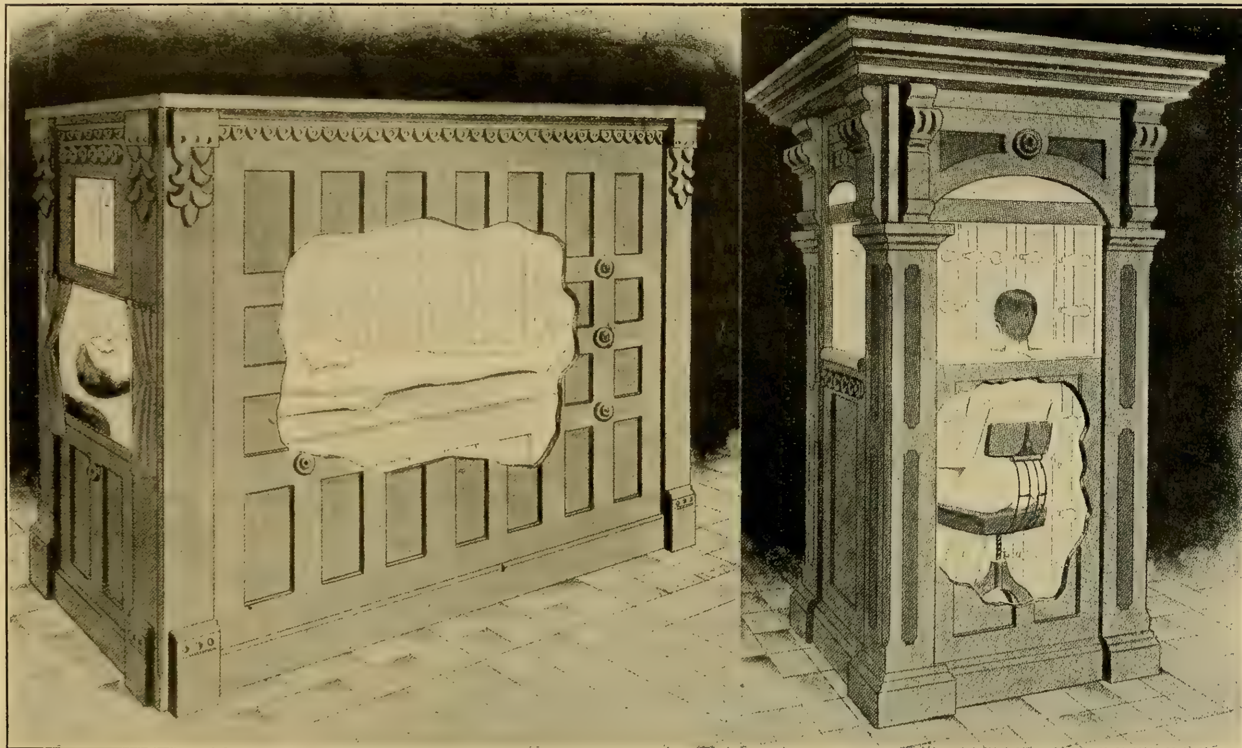


Plate 226.—Showing positions of patient in horizontal and upright cabinets during treatment.

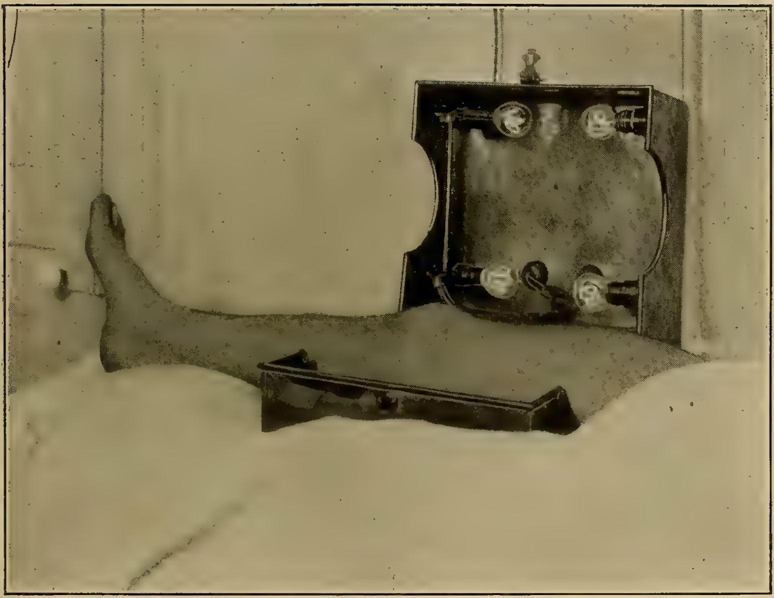


PLATE 227.—Electric-light box for local application to any part of the lower extremity. Place the affected part in the field of light rays, close down the cover of the box and turn on the current.

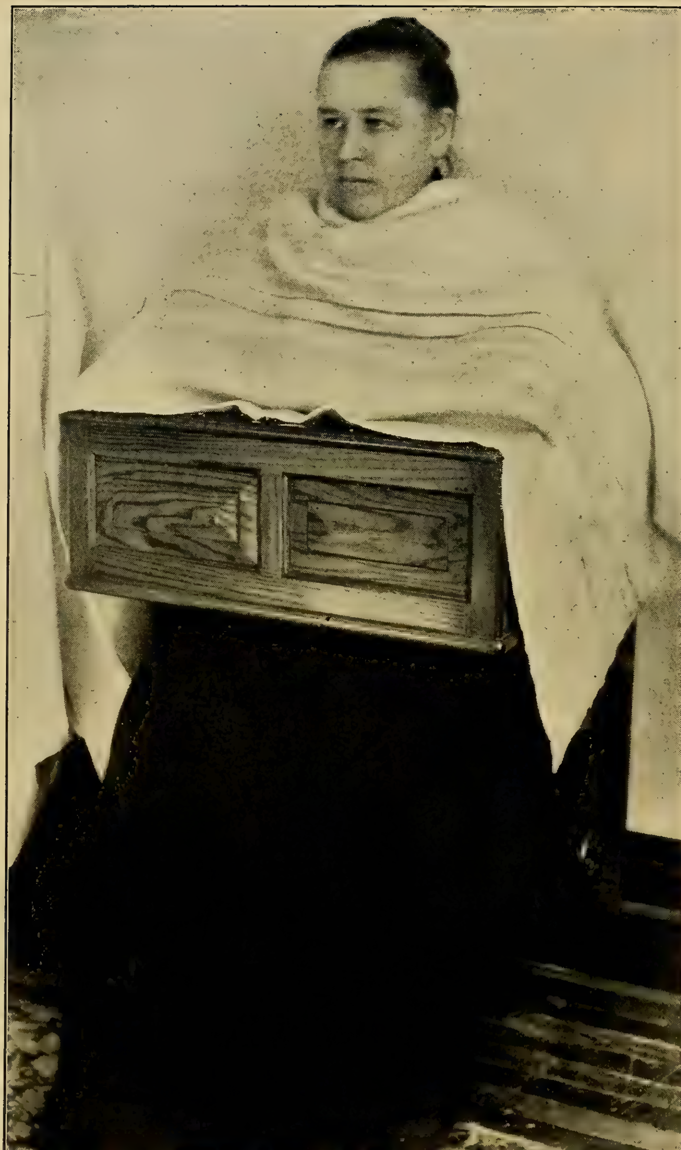


PLATE 228.—Local Electric-Light Bath to Trunk of Body. Remove clothing from the abdomen, sit patient with the exposed part against the open side of the box containing the lamps, throw a blanket over the chest and shoulders, and turn on the current.

"*Electric-light bath:* temperature of bath, 34.5 degrees C. (94 degrees F.). Internal temperature of subject before the bath, 36.6 degrees C. (98 degrees F.). Surface temperature, 35 degrees C. (95.44 degrees F.). Patient began to perspire after one minute. At the end of five and a half minutes he was removed from the bath. The temperature was taken at once and the internal temperature was found to be 37.5 degrees C. (99.6 degrees F.); the surface temperature, 37.9 degrees C. (100.2 degrees F.). Ten minutes after the bath the mouth temperature was 37 degrees C. (98.5 degrees F.); and the axillary temperature was 36.6 degrees C. (98 degrees F.).

"*Turkish bath:* temperature of bath, 70.5 degrees C. (159 degrees F.). Temperature of the subject before the bath, 36.4 degrees C. (97.4 degrees F.); axillary temperature, 96 degrees F. Perspiration began in five and a half minutes. Immediately after the bath, the mouth temperature was found to be 37 degrees C. (98.7 degrees F.); axillary temperature, 37.2 degrees C. (99 degrees F.). Ten minutes later the mouth temperature was 37 degrees C. (98.8 degrees F.); axillary temperature, 36.6 degrees C. (98 degrees F.). From these statements it appears that the incandescent electric-light bath is far more effective than the Turkish bath in raising both surface and internal temperature, which clearly indicates the penetrative power of the intense heat-rays of the electric-light.

"5. *The Blood.*—The effects of the incandescent electric-light bath upon the blood were determined by a careful count of the corpuscles by Gower's instrument and a determination of the hæmoglobin by the hæmatoscope of Henocque. The figures obtained showed no very marked increase in either blood-corpuscles or hæmoglobin, although in one case the number of corpuscles was increased nearly 200,000 per cubic millimetre.

"The physiological effects of the electric-light bath* are chiefly those of heat, and do not differ very essentially from the effects obtained from other sources of heat, except that the electric-light bath is a much more efficient and convenient method of administering heat than any other which has been devised, with the exception of water, which doubtless has a wider range of use. The purposes for which heat is applied are usually two:

"(1.) The induction of perspiration.

"(2.) The stimulation of protoplasmic activity, and thus increase of tissue metamorphosis.

"In the incandescent electric-light bath the heat enters the body directly as a radiant force, instead of by the slow method of convection and conduction, thus more rapidly raising the temperature of the blood, and hence quickly inducing perspiration. That heat stimulates vital activity is a fact which every one who has ever studied the amœba, or white blood-corpuscle, upon the warming stage is well acquainted.

* Using whole mixed light from the ordinary sixteen candle-power commercial lamp. Special therapeutic lamps have widened the range of action as is noted elsewhere in this section.

The effect of poultices and fomentations in producing pigmentation of the skin, as well as the effects of intense heat, either from the sun or other incandescent sources upon the complexion, afford further evidences of the important physiological effects of heat. Entering the body directly, instead of slowly working its way through the poor conductors which are found in the successive layers of tissue which compose the covering of the body, the radiant heat of the incandescent electric-light stimulates and vitalizes the tissues to a high degree.

"*Therapeutic Uses.*—I have found the electric-light bath of far greater value in the treatment of a great variety of maladies than any other means of applying heat, except water, and find that it may be much more generally employed than the ordinary Turkish, Russian, vapor, or hot-air baths. One reason of this is the convenience and rapidity with which the degree of heat employed may be graduated by turning on or off one or more groups of lamps, by which means the amount of heat is rendered absolutely and instantly controllable. The source of heat relied upon is the incandescent filaments of the lamps rather than a heated atmosphere, and hence is easily and instantly controllable. The instant the lamp is turned off, the heat which it has previously emitted is withdrawn from operation. If additional heat is required, the desired number of lamps may be turned on and become instantly operative.

"Another reason for the more universal application of the incandescent electric-light bath is the fact that when properly applied, its effects are *highly tonic in character.* A short application of the bath at full force for a time *just sufficient to induce powerful stimulation of the skin without provoking perspiration*, is one of the most effective means of peripheral stimulation with which I am acquainted. The tonic effects of such an application may be still further intensified by instantly following the bath with a cold spray or other cold application, thus producing a revulsive effect of the most agreeable and effective character. The excessive heating of the skin prepares the way for the cold application, without at the same time so overheating and relaxing the blood-vessels as to render recovery of the tone of the cutaneous tissues so tardy as to involve the risk of exhausting the patient too greatly or exposing him to the liability of taking cold.

"Still another special advantage of the incandescent electric-light bath over other sources of heat is the facility with which it can be localized. In this respect it is far superior to fomentations or any other local application of heat. By means of suitable appliances, the heat can be focussed upon a small point if desired, and affects not only the surface, but the deeper tissues. I am sure that the radiant energy of the electric-light penetrates the tissues to a depth of several inches. This I proved by actual observation, as before intimated. For deep-seated pain, as well as for the relief of hyperæsthesias of the skin, I know of no remedy more valuable. Many applications of this sort have been made by myself and my colleagues, several thousand in all, and I have constant reason to be grateful for the acquisition of this therapeutic measure, as it has afforded relief to many cases which have stubbornly resisted all other therapeutic means which I have been able to employ.

" *Rationale of the Effects of the Incandescent Electric-Light Bath.* —The peculiar value of the electric-light bath I consider due to its efficiency as a *source* of radiant energy. The heat is derived from the electric-light by radiation, and not by conduction. The skin, as well as the air, is to a large extent transparent to radiant heat, and the same is true of all the living tissues. This is evidenced by the phenomenon of transillumination. By a speculum placed in the vagina or rectum and a suitably arranged electric-light of sixteen or thirty-two c. p. placed over the abdomen, I have seen the whole interior of the trunk illuminated and made to glow with a bright red light, the red color being due to the reflection from the red corpuscles of the blood. Even the bones are transparent to light when in a living state. This is clearly shown by placing the hand between an electric-light and the eye, with the fingers in close contact; the hand being placed near enough to the light, the whole fingers will be seen to be illuminated by the light, and not simply the soft parts.*

" One of the great advantages of the radiant heat or incandescent electric-light bath over the Turkish, Russian, vapor, or similar forms of bath, is the fact that the body can be subjected to the most intense heat desired without confining the patient, and without overheating the atmosphere surrounding him. This is due to the well-known fact that rays of heat pass through such transparent media as the air without heating them.

" So far as I know, an empiric in Cincinnati was the first to make use of the arc-light for therapeutic purposes. His use of the bath, however, was in connection with the 'blue glass' fanaticism which spread so extensively over the country a few years ago, the electric-light being substituted for sunlight, a very uncertain quantity at some seasons of the year. In 1890 one of my colleagues, Dr. Kate Lindsay, called my attention to the personal benefit derived from the use of the heat of the electric-light obtained by the application of a lamp in contact with the body and covered in such a way as to collect and retain the heat derived from it. I learned from several other persons of similar effects obtained in the same way, and at once had constructed a variety of devices for applying heat to the different parts of the body, and also for general application.

" The first bath for general application consisted of a bank of lights, between thirty and forty in number, arranged upon a frame which was hinged upon the wall in such a way that it could be raised and folded back against the wall while the patient was placed upon a suitable couch beneath it. The patient being in readiness, the frame

* Since this was written photographic tests have demonstrated the penetration of the chemical effects of light rays through the trunk of the body, as elsewhere cited in this section.

was lowered to a position about six inches above the body of the patient, and the space about the patient inclosed by means of curtains which dropped from the edge of the frame carrying the lights.

"The second form of bath which I had constructed soon after, consisted of a cabinet about eight feet in height upon the inside of which were placed between fifty and sixty incandescent lights arranged in rows, the spaces between the rows of lights being filled with silvered glass so as to multiply the number of lights to an infinite number by reflection. The cabinet is so arranged that the whole body of the patient, including the head, can be exposed to the influence of the light, or the head can be excluded, as in the ordinary vapor-bath. The cabinet is freely ventilated, and by means of switches and a proper grouping of the lamps in wiring, the number of lights in use can be instantly and perfectly controlled. A description of this bath was published in a German medical journal by Dr. Gebhardt, who visited the Sanitarium and personally tested the bath in 1892.

"The third form of bath for general application of the incandescent light, which I have had constructed more recently, consists of a cabinet lined with mirrors and containing some sixty incandescent lights, so arranged that the patient lies in a horizontal position, the lights being placed on three sides. The patient lies upon a suitable couch with rollers, which is pushed entirely within the cabinet, or only so far as to expose such portions of the body as it is desired to bring under the influence of radiant light and heat. By this plan the influence of the light can be confined to the feet and legs, or any other portion of the body up to the neck. It is only necessary to protect, by a sheet and a piece of mackintosh, any portion of the body which it is desired to exclude from the action of the bath. I have also had constructed and have in use special appliances by means of which applications may be conveniently made to the spine, the trunk, the feet, and other parts of the body. After ten years' use of the electric-light bath in a great variety of ailments, I esteem it as of greater utility than any other means of applying heat to the body, with the exception of water, the universal applicability of which gives it paramount value over all other therapeutic agents which can be employed for this purpose." (Kellogg.) (Plates 221 to 229.)

Methods of Treatment.—The following directions and Instruction Plates were prepared especially for this work by Dr. J. H. Kellogg, whose cordial assistance is here gratefully acknowledged by the author.

"The Instruction Plates in this section show the following forms of our Electric-Light-Bath Apparatus:

The Horizontal Cabinet for treatment of the entire body with composite light-rays from incandescent lamps.

The Upright Electric-Light-Bath Cabinet for similar treatment in erect positions.

Local Applications to feet, spine, and trunk of body.

Plate 229.—This plate shows the feet of the patient undergoing light treatment in a foot cabinet, while at the right on the wall is shown a vertical box containing lamps for treatment of the spine. In each case expose the part, apply it in the field of light-rays, cover the adjoining tissues, and turn on the current.

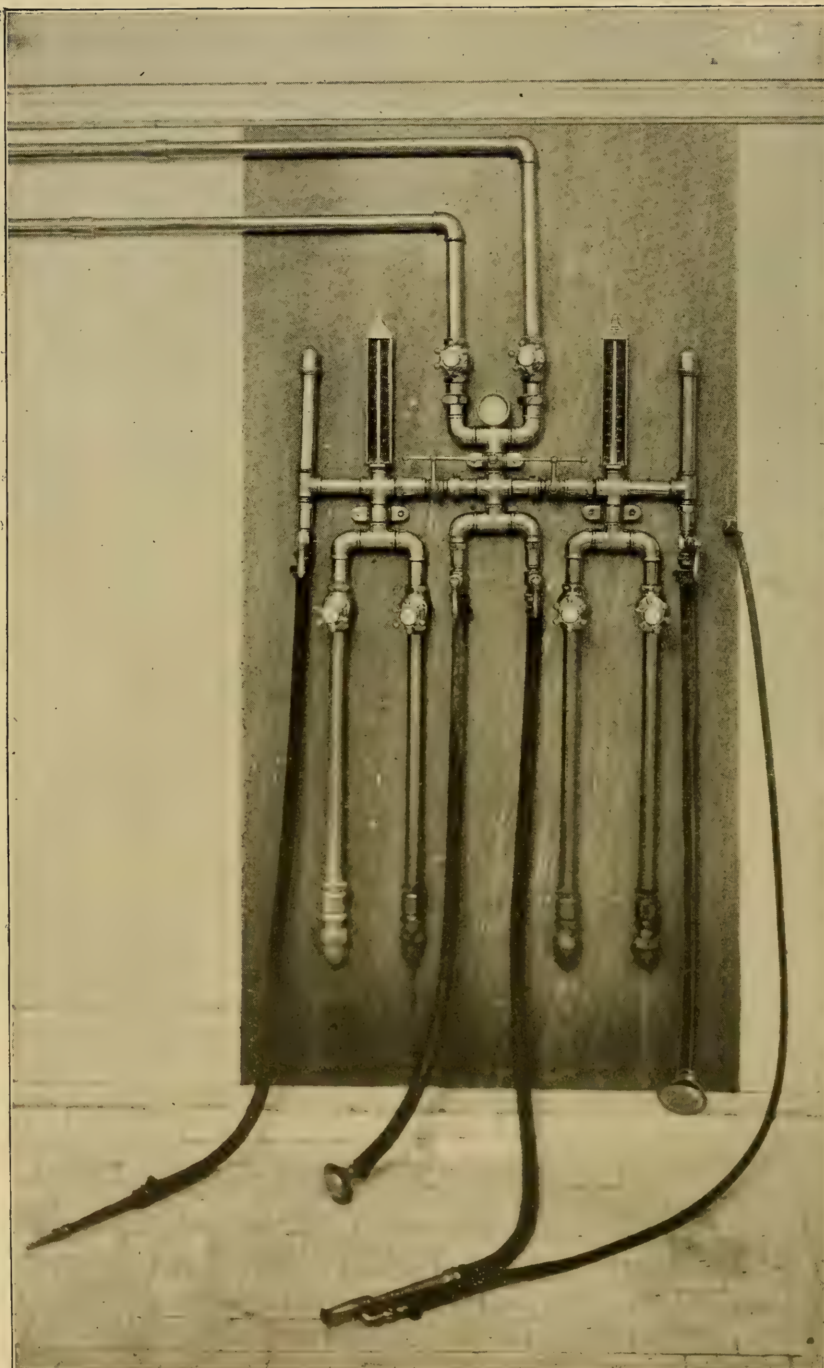


PLATE 230.—Dr. Kellogg's Douche Apparatus for "After-treatment" of cases coming from the electric-light cabinet.

PLATE 231.—The series of six Instruction Plates immediately following illustrate the hydro-therapeutic applications which suitably complete the administration of Radiant-Heat Baths. Each step of the procedure is taught in the text. This plate shows a patient receiving a "Cold-Mitten Friction."

PLATE 232.—A "Cold-Towel Rub" to chest after treatment in a Radiant-Heat Bath.

Leg and Arm Apparatus.

Arc-Light Cabinet.

For the treatment of patients in these various luminous and radiant-heat baths, both local and general, the technic is divided into two important parts which must closely supplement each other in order to secure satisfying results. Referring to other portions of this section for the actions ascribed to therapeutic luminous rays we will here state the direct treatment in the bath and the important after-treatment which concludes the séance properly.

Preparation of the Patient for General Bath.—Remove the entire clothing. Lave the face and neck in water of 60° F. and apply a moderately thick compress of cheese-cloth dampened in water of the same temperature to the scalp and frontal region, as shown in the Plate. If there is a decided tendency to cerebral congestion a cold towel, or compress, or ice-collar, should also be applied to the neck. Before the patient enters the bath care should be taken to have the feet warm. If cold, they may be warmed by a hot foot-bath for five minutes, or by the application of electric-light to the feet.

When all is ready for the treatment draw the rolling couch out of the cabinet and have the patient recline upon it so that the feet will enter the cabinet foremost. Support the head comfortably with suitable hair pillows. Then push in the couch, turn on the desired number of lamps, and adjust the dose.

The *duration* of the luminous-heat bath or tonic electric-light bath will depend upon the effect desired. For simple tonic effects, or as a preparation for the application of cold, the duration should not be more than three or five minutes—or just long enough to secure a reddening and slight moistening of the skin. If it is desired to produce vigorous perspiration the patient may remain in the bath fifteen or twenty minutes, or even longer. If, however, the duration of the bath is greatly prolonged the intensity of the dose should be reduced by lessening the number of lights, or by diminishing the luminous power by a rheostat. The temperature of this form of bath is taken with a thermometer (the bulb of which is covered with lamp-black), placed upon the fully exposed abdomen of the patient. Temperatures ranging from 160 F. to 350 F. or even higher may be employed. After removing the patient from the bath a cold application of some sort should be made in all cases in which there is not some special contra-indication prohibiting the use of cold; as, for example, cases in which it is desired to prolong perspiration after the bath by means of a dry pack, or acute, inflammatory cases in which the patient is wrapped in blankets and allowed to cool gradually.

Hydriatic Applications to Follow the Electric-Light Bath.—*The electric-light bath enormously dilates the surface vessels and excites cutaneous activity to the highest degree.* The normal tone of the surface circulation may be best restored by the application of cold water. Cooling by evaporation through exposure to the air is detrimental, and even dangerous, unless the patient actively exercises continuously during the cooling process, for the reason that the slow evaporation which takes place causes prolonged chilling of the surface, and spasm of the vessels, which results in visceral congestion and the total loss of the *tonic effect* which it is, in most cases, desirable to secure by this bath.

Perhaps the most efficient of all hydriatic applications for cooling a patient after an electric-light bath, is the *douche*. Either the rain douche, or shower bath, or some form of the horizontal douche (broken douche, fan douche, or spray), or the multiple douche may be employed. A thoroughly equipped electric-light treatment-room should certainly be also provided with a suitable douche apparatus. The author's douche apparatus is shown in the Instruction Plate 230. This device provides for exact dosage by means of pressure-gauges and thermometers, and it is so arranged that water of all practical temperatures may be applied; hot and cold water may be employed alternately or simultaneously. When a douche apparatus is not available, a wet-hand rub, a cold-mitten friction, towel rub, or wet-sheet rub, may be employed. The method of the application of these several procedures is indicated in the Instruction Plates. For fuller instruction in the administrations of water the reader is referred to the author's work on Hydrotherapy,* but the essentials of technic are as follows: (See Plates 230 to 236.)

A Cold-Mitten Friction.—This is a cold application and is applied by means of a cold mitt or sack made of haircloth or moreen. This is dipped in cold water at a temperature of 60° F. and applied with vigorous friction to different parts of the body in succession. Each part is rubbed until red, and thoroughly dried before proceeding to the next part. Usually water at a temperature of 60° F. is employed first. The temperature is lowered one or more degrees daily, until a temperature of 40° F. is reached. The patient's face should be moistened by the hands dipped in cold water before beginning the application. This procedure is best adapted for feeble patients, or those who cannot react to the general cold application, or to the more vigorous tonic measures. (Plate 231.)

The Cold-Towel Rub.—In this application the towel is rung out of

* "Rational Hydrotherapy," by J. H. Kellogg, M.D.

cold water and quickly spread out over the bare skin, and then rubbed by the hands of the attendant, while the patient holds the towel in place. The movements of the hands are made from above downward and in one direction only. The rubbing is alternated with percussion and is continued until the towel is warm. A dry towel is applied and the dry parts rubbed until warm, and the application is then extended to other parts of the body—the arms and legs—one at a time; and then to the back and sides of the legs. The cerebral circulation is protected by cooling the patient's neck with a napkin dipped in cold water. This is a most excellent hydriatic procedure and is adapted to patients who have a fair degree of reaction. The cold-towel rub follows in natural succession after the cold-mitten friction. The temperatures employed in the cold-towel rub are the same as in the cold-mitten friction. Great care should be taken to secure a good reaction of each part before proceeding to another part. Plates 232 and 233 illustrate this application.

Wet-Sheet Rubbing.—In this procedure the patient stands enveloped in a wet sheet while the attendant alternately rubs and spats the outside of the sheet. The sheet is wrung out of cold water at a temperature of 65° F. to 50° F. The rubbing should be continued until the sheet is warm. As the patient acquires the power to react the temperature of the water is lowered, and the sheet, by less wringing, is allowed to contain a larger amount of water. The application is best made by two attendants, one rubbing the upper part and the other rubbing the lower part. Care should be taken to bring the sheet in contact with the skin everywhere, as thoroughly as possible. There are three steps in this procedure, as shown in Plates 234 to 236.

Application to the Feet and Spine.—In applying the electric-light bath to the feet the patient's limbs are uncovered to the knees; the legs are placed in a small lidless box, each side of which is furnished with electric lights. The bath is continued until the skin is thoroughly reddened and local perspiration induced. In some cases general perspiration occurs. This procedure should be followed by a cold application to the feet and legs, or to all the surface *which has been reddened by exposure to the luminous rays.* The ordinary duration of the bath is from ten to twenty minutes. Its chief utility is in cases of rheumatism, or gout of the feet and ankles (the gout being acute or chronic), tuberculous diseases of the bones or joints, chronic inflammation of the structures of the joints resulting from sprain, bruises, or other traumatisms. A higher temperature may be secured in this form of bath than *by any other known means.* Some French physicians reported observations of a temperature as high as 500° F. It is impossible to safely reach so high a temperature, or so powerful a stimulation of the tissues by hot air, steam, hot water, or any other known means.

Local Applications to the Spine are exceedingly useful in many cases of chronic spinal neuralgia; also of spinal diseases accompanied by congestion or irritability. The patient sits on a stool in front of the apparatus, which is attached to the wall. The duration of the application should be from ten to twenty minutes, or until the skin of the back is thoroughly reddened. The application to the spine should be of sufficient duration to secure a change of the dusky red color induced by heat to the brighter red color resulting from the reaction of cold. Not infrequently general perspiration is induced, which requires the cold application to the general surface, and the cold-towel rub and the wet-sheet rub to tone up the general surface and prevent taking cold. A reaction following the general cold application greatly assists the effect of the local application to the back. The cooling may be effected by means of the cold-mitten friction and cold-towel rub, or by pouring cold water upon the parts, or, best of all, a cold spray. The temperature of the water may be 60° F. to 50° F., or even lower. A short cold application is more effective than a prolonged cold application, especially when the measure is applied for derivative effect, as in cases of insomnia, in which it is desirable to fix as much blood in the lower extremities as possible by relaxing the cutaneous vessels, which are often found in a state of chronic spasm. This bath renders great service in cases of this sort; it is more rapidly and efficiently active than the hot foot-bath, or any other similar procedure.

The Electric Light for Joints.—The electric light affords the most efficient of all means of combating morbid processes in the joints; it may be applied to the knee, ankle, elbow, wrist, finger, and to other joints. Various special devices admit of the application of the light to the hip-joint and the cerebral articulations. The instrument may be closed so as to superheat the air about the joint; but this is not always necessary. The highest temperatures are attainable only when there is a free circulation of air, so that the air in contact with the skin is always dry. By this means it is easily possible to obtain a temperature of 400° F. or more. A temperature, much lower than this, however, is not tolerable when the air is saturated with moisture.

The *after-treatment* following the application of the electric light to a diseased joint must be determined by the pathological conditions present and the effect desired. In *acute* cases it is important to maintain the highest possible degree of activity of the circulation so that

PLATE 233.—"Cold-Towel Rub" to arm. With this plate and the text the process may be carried out by any nurse.

PLATE 234.—The next plates illustrate the three steps of accomplishing the "Wet-Sheet Rub" as a finish to the Radiant-Heat Bath. We here witness the first step; patient standing in tub with dripping sheet being thrown around him.

PLATE 235.—Showing the second step of the "Wet-Sheet Rub."

Plate 236.—Third step of the "Wet-Sheet Rub" as an "after treatment" to the Radiant-Heat Bath.

the blood may be diverted from the internal structures. This is best accomplished by wrapping the parts in a thin linen towel wrung out of cold water at 60° F., covered first with a mackintosh, and then with several layers of flannel. The mackintosh should be made to fit the skin closely above and below, so as to avoid evaporation and chilling. In *chronic* cases accompanied by exudate without pain, a light bath may be followed by the spray or douche with cold water, lasting from thirty to sixty seconds. In the absence of a douche apparatus the water may be poured upon the knee from a basin held as high as possible while the limb is supported over a tub. Alternate compresses may be applied, instead—that is, immediately following the application of the light bath, a towel wrung out of cold water at a temperature of 60° F. may be placed about the joint for twenty to thirty seconds. This may be followed by a *hot* fomentation, and a return of the light-bath for four or five minutes, or until the part is well heated, when the cold compress may be reapplied. The procedure should finish with an application of the cold compress for thirty seconds followed by rubbing (the whole surface receiving thorough massage), and the application of dry woolen bandage extending well above and below the knee, and of sufficient thickness to maintain the activity of the surface circulation."

Studies in Facts and Faults.—Dr. Wilhelm, of the Bertheldorfs Sanatorium, Germany, strongly champions the incandescent electric-light bath. He instructively reminds us that a photographer must not examine a sensitized plate by the light of a candle unless he has, by a red screen, deprived the candle of the actinic (chemical) rays; and if a single candle has so much chemical energy that it will fog a plate, how much more then has an electric-light bath cabinet grouping 800 candle-power of light-rays round a patient's body! As so few medical readers are fully informed of the A B C's of this subject it will not be without interest to dwell a moment on the facts set forth in Wilhelm's paper.

"Blue light that cures lupus, proceeding from the extreme actinic end of the spectrum, and red light that favorably influences the exanthemata (small-pox, measles, scarlet-fever, and various skin diseases), from the opposite end of the spectrum, meet—*extremes meet*—in skin therapeutics and act specifically as distinct kinds of light, each in its own way. If we consider a photo-electric cabinet lighted by a cluster of fifty incandescent lamps of sixteen candle-power each, the extraordinary similarity of the effects with those of the sun must strike any one, and if we imagine these lamps—sufficient to light an entire villa—collected for therapeutic purposes around a single patient in a space not three feet in diameter and not much more in height, we think that this concentrated energy of 800 candles justly deserves the name of 'light bath,' and cannot be put in the ordinary category of a mere 'sweat bath.' Moreover, we can now fix the lamps invented by Professor Nernst* in Edison's sockets, and they give us double the amount of light.

"We not only thus obtain a light twice as intense, but a light derived rather more from the actinic side of the spectrum and furnishing what is now considered the preferable source of mixed light for therapeutic purposes. Looking over the lists of those who have already installed this incandescent, or Nernst lamp cabinet bath, we find the name of many a colleague of very critical turn of mind, and it is scarcely necessary to point out that a physician, before making so important an order, obtains all the information available. Every German physician who uses X-ray therapy will appreciate the great value of the actinic rays, and will also recognize the merits of the Finsen therapy, but will desire in many cases expressly to avoid the inflammatory reaction, the pigmentation of the skin, etc., without giving up the other therapeutical uses of light. And nothing will better accomplish this object than the incandescent mixed-light bath, with its relatively small total of chemical-rays. With the usual incandescent one-half ampere (sixteen candle-power) lamp the proportion of luminous rays to electrical energy consumed is about thirty per cent. The Nernst one-half-ampere lamp raises this to sixty per cent., while the arc-light gives about eighty-five per cent. By means of the red blood our body absorbs the actinic blue and violet rays immediately below the surface according to the *law of color absorption*, while as *brilliant light* the other rays penetrate even through bones to the innermost parts. Why should these red rays not act favorably on the inside of the body as they do on the outside? Considering light-rays as divided into three classes for therapeutic uses—heat, luminous, and chemical—and comparing their range in terms of the musical scale, we may say that whole light extends over about four octaves.

"1. Luminous rays occupy about one-sixth of the total.

"2. Heat-rays occupy the lower two octaves and contain the red and ultra-red.

"3. Chemical-rays extend chiefly from the blue to the invisible end of the scale.

"To avoid confusion between common speech and technical expression it is very necessary to distinguish invisible heat radiations which are strictly *rays of heat*, and hot luminous rays from the red end of the spectrum. It is because all normal-sighted men first perceive red rays as light and not as heat that red lights are so universally used as signals. Moreover, it is not only general theoretical considerations which lead us to distinguish heat from red light, but therapeutics compel us so to do. In all other hot baths the heat reaches the interior of the body by *conduction* after slowly penetrating through

* Nernst lamps have been used somewhat in this country since 1900 and are familiar to all who read Electrical periodicals, even if they have not yet seen the beautiful light itself.

the superficial layers which oppose great resistance to the passage of ordinary heat rays, but which allow light rays readily to pass. Therefore, the average duration of a hot-air bath is and must be two or three times as great as that of an incandescent-light bath of mixed luminous, chemical, and heat radiations. It is very properly the qualities of light as *light*, which have gained for the latter its claim to preference. We agree perfectly with the view that a portion of the light rays are transformed in the body into heat, and on this account incandescent mixed-light baths can render excellent service as sudation baths, but we are not obliged to let them act so powerfully or so long. *We can regulate the dosage.* In every well-arranged cabinet any or all of the lamps can be inserted or removed at will. They can be turned on or off at will. The duration of the bath can be prolonged with a few lamps if desired. Beginning with the full light till the patient is comfortably warmed we can then reduce the number one-half, or one-third, and control the heat without making him lose the beneficial action of light *per se.*

"Per contra; light rays enable a higher temperature to be more easily borne. 'Under the influence of electric-light,' says M. Siemens, 'plants can bear a powerful stove heat without losing their vigor.' From my personal experience I can affirm that in an incandescent-light bath I can easily support a temperature of 75° C., while in ordinary heat baths malaise appears at 45° C. But, not to protest against the excellent practice of employing incandescent-light baths as sudation baths, but to maintain their importance as true *light* baths and preserve the name they justly deserve as such, let us keep clear the two facts:

"1. The thermometer rises in the ultra-violet end of the spectrum as well as in the red.

"2. *All* the luminous rays, including the red, possess a chemical action.

"On account of a lively reaction on the skin in whole-light baths, transpiration occurs at comparatively low external temperatures, but this does not imply that they are sweat baths alone. The common term 'electric-light bath' is scientifically inexact at this stage of the development of photo-therapy. All observers should now state in their publications whether they speak of whole incandescent light, Nernst light, arc-light, or any form of light filtered through red, blue, or other special decomposing media. The subject has outgrown the empirical term and calls for scientific terminology."

When a patient has derived benefit from skilled *light* treatment with special incandescent lamps, Nernst lamps, or the large arc-light a distant practitioner cannot expect to give him the same results with a primitive incandescent cabinet fitted only with commercial sixteen-candle-power lamps. The effects of active alkaloids cannot be duplicated by domestic herbs, and the same principle applies to photo-therapy. The question between inferior apparatus and scientific instruments has long been in the fore of electro-therapeutics, and, young as is photo-therapy, it already suffers from the same cause. It is eminently desirable that treatment should be successful and failure in equipment or technic will spell failure in effects on the patient. Recently a Berlin physician devoted a few words to this feature of practice, and what he says can instruct any who desire to learn.

"The early and disastrous confounding of incandescent-light baths with blue arc-light baths rested upon the primitive opinion of *hydropaths*, who first regarded all light as equal and all light-baths as merely sweating baths. This mistake was soon corrected, but the uninformed still propagate the error. The experimental proofs of the different action of the rays of the spectrum have been given by Finsen, and clinical proofs we have brought forward in a report of observations which now include 4,000 cases, with notes on pulse, temperature, respiration, etc. It is still too frequent that physicians fail to distinguish between the fundamental factors of photo-therapy. It has happened that patients with old knee-joint effusions, which had been benefited under our care, have relapsed after some time or excessive exertion, and have taken a series of light-baths elsewhere. They have, perhaps, been disappointed at not seeing the 'brown mottling' (the reddish-brown string-like discolorations), which they have been accustomed to observe on the spot, especially under local radiation, and which is the first sign of lymph-cell activity and commencing absorption. On inquiry it has been found that these patients have really had only a general exposure in a commercial incandescent-lamp cabinet with neither arc-light, reflectors, nor regulated dosage; or, perhaps the arc-light was there but no *reflector* concentrated the filtered rays on the special spot, and suitable combined treatment was not carried out. These patients then had simply had a sweat, with little or no local effect. This is not true photo-therapy.

"Also, proper treatment after the *whole* or *filtered*-light baths with reference to hygiene, massage, gymnastics, rest, diet, and hydrotherapeutic measures must be employed on intelligent medical principles to make up a complete treatment of scientific character, according to the indications. No branch of photo-therapy should be left to a non-medical assistant. The physician should give the treatment his personal supervision and direct the dosage.

"There should be no light bath without subsequent douching of a special kind, and of a proper temperature. No light bath should be given (nor any hot-air bath) without due regard to the time since the last meal, the condition of the stomach and intestinal tract before the bath, and the regulation of the diet after treatment. The principle here is the same as in practically all forms of treatment by heat, water, or actions which disturb the temperature and circulation. An hour after a small meal, or two hours after a hearty meal, is a safe rule for patients to wait before treatment.

"No *light* bath should be given without careful discrimination between the indications for the arc or incandescent, or whole, or filtered, light; and only the newer and most improved modifications of apparatus should be employed. Reflecting mirrors in cabinets should be tin-foil and never mercury-coated glass. And after the bath the physician should utilize to the best advantage the appetite, thirst, and inclination for exercise, that must follow the excretion of a kilo. of sweat, secreted in a quarter of an hour."

CHAPTER XLVII

PHOTO-THERAPY: LIGHT RAYS WITH PREDOMINATING RADIANT HEAT

The Dowsing Radiant Heat and Light Treatment. Clinical Reports. Complete Studies of Physiological Actions. Therapeutics.

In the preceding chapter we have considered *whole* light in general treatment without regard to special filaments and construction of the incandescent type of lamp. But we need not limit ourselves to the regular commercial light, for we find that the proportions of certain rays in whole light can be varied at the source by altering the quality of the material which forms the glower and by operating the glow in special media. This simple discovery puts a new phase on the subject of Light-treatment. Foremost among the newer modifications, which aim to supply an increased dosage of the rays which contribute to the production of tonic and nutritional warmth for physiological effects, has been the combination of about ten electric glowers mounted in polished reflectors which constitutes the apparatus we shall next describe.

The Dowsing Radiant-Heat and Light Treatment.—This new form of light apparatus had its origin in attempts to solve the problem of cooking and of heating rooms by electricity. At the suggestion of a London physician the electric stove of Mr. H. J. Dowsing was modified into a therapeutic instrument of the first class, and points the way to a still greater development in the future of luminous rays with selected medical properties. The lamps of the apparatus, which radiates "warm sunshine," are sections of white opaque glass tubing closed at the ends and possessing a glow-filament of special composition in which lies the secret of the great generation of heat-rays. The vacuum tubes are made of any required form, for both direct and alternating currents of any voltage in street-circuit use. In the smaller local apparatus, one or two tubes are mounted with *reflectors* which direct the rays on the part. The "body" apparatus is built up out of a series of "units" connected so as to treat the entire body. The patient is undressed and laid on the mattress and covered with a large sheet and quilt. The reflectors are adjusted to each side of the bed and across the feet. The quilt is raised from contact with the patient by supporting rods and is closed snugly around the neck, thus leaving the head out in the cool air while the radiant heat is retained and applied to the patient. The patient enjoys the bath with the head cooled in the usual way. Of this apparatus a Berlin physician writes:

"Those of you who have seen and examined this apparatus must confess that it produces a very splendid radiation of dry luminous heat with advantages which no other heat-producers possess. It develops a heat of 250° F. to 300° F. in a few minutes. This heat I have myself witnessed from both the large and local lamps. The 'heating radiator' with these lamps is a very useful *stove* which you can place anywhere in your consulting-room and make it a very agreeable as well as the most practical medium for warming not only the room in which you treat your patients, but for warming bodily the patient himself so that the undressing for a physical examination is pleasant. *I always make use of this radiator for warming the extremities of patients when beginning to massage them*, otherwise it often takes a long time to increase the circulation of the feet and toes. In winter and on cold days patients long to get under the rays of this radiator, which spreads its pleasant warmth immediately when the current is turned on. No discomfort is felt even when the heat is raised, as it can be, from 200° F. to 500° F., the heat being absolutely dry. *There are no deleterious products of combustion.* As soon as the current is turned off the lamps become dark and cool, and no trace remains of their having been in action. They are very little trouble. The heat, as heat, does not burn in the ordinary way. You feel it as warmth, but it does not sting and burn. I have carefully taken the temperature of patients before a full body bath and just before I turned off the current, and have found a rise of from 2° to 7° F. within thirty-five to forty-five minutes' treatment.

"Since introducing this apparatus in my house I have treated, and am now treating, patients with all kinds of ailments, from incipient colds to complicated and very obstinate sufferings. Neuralgias and rheumatic pains, when local only, often begin to disappear during the first séance, and these patients are charmed. If colds in the head, throat, and chest, if internal congestions in all organs have been cured by inducing perspiration and setting up a profuse action of the capillaries of the skin, then surely these radiators of luminous heat fulfil all requirements, while they have advantages which must be kept in mind. You may riddle your naked patient with luminous rays and without any cover over him, and he will tell you he enjoys it like basking in the sun.

"In this bath you do not breathe vitiated air as in Turkish baths nor the exhalations and expectorations of other patients sharing the same bath-room. You do not want to use water after the perspiration, but are briskly rubbed down and dried over the whole body with dry towels, so that even kidney cases remain entirely free from the external use of water, which is in this and many other cases a precaution to be highly appreciated. To those suffering from weak heart and circulation, or from heart disease, this treatment appears not to produce the slightest cardiac depression even in the very feeble and debilitated. It is indicated even in some cases of chronic heart mischief, as well as in chronic pericardial and pleuritic adhesions, chronic bronchitis, and complaints that lead to superficial decarbonization of the blood in the lungs. Among the most favorable cases published are acute as well as chronic gout and rheumatism, chronic articular swellings, pains and stiffness, adhesions, uric-acid deposits, callus after fractures, exudations after dislocations, sprains, contusion, and other traumatisms, besides a host of other complaints of a peculiarly distressing nature. A surgeon has applied dry heat of 300° F. to an inflamed joint with benefit to the inflammation, soothing the pain and easing the patient in a remarkable manner; and further experience has proved that more can be done in one hour in this way than by a week of the old fashioned poultices and fomentations." (V. J., M.D., M.R.C.P., Lond.)

To still further acquaint the reader with medical experience with this apparatus we shall cite two or three other expressions upon its clinical use. They are both recent and authoritative.

"I have treated a lawyer, whom Dr. Bennett sent me on April 12th this year, for very obstinate lumbago of five weeks' standing, with massage and with these luminous heat radiation full baths, which brought him first within ten minutes (later on within five minutes) into perspiration. His temperature before the bath was 98.8°, his pulse 88, his respiration 22, and the specific gravity of urine 1026; uric-acid deposit. After thirty-five minutes' most profuse perspiration in the covered bath his bodily temperature showed under the tongue 102° F., his pulse 108, his respiration 16. On April 21st he had been able to walk long distances and he had improved very greatly. He had then but one bath a week, and his temperature went usually up, from before the bath to the end of his perspiration, between four and five degrees. At last I pronounced him cured, and in the next bath, on May 19th, he, being naked, was riddled with luminous-rays, and he enjoyed this bath immensely, his temperature increasing after thirty-five minutes in the bath to 99.5° F. and not more. The window of the room remained open all the time, and after twenty minutes' rest he got up with his temperature normal, pulse 72, his urine then being clear and of 1018 specific gravity, and he walked out in laughing mood, jolly spirits, and whistling.

"I always observed that after the bath patients feel more vigor, vitality, and enjoy better spirits. In applying the heat in this manner, *i.e.*, in the nude state of our body and without any cover, the air cannot be charged with moisture at all, as the heat-rays disperse and absorb it; then, of course, you do not see the perspiration so profusely on the body except on those parts which the rays do not project upon, such as the head and face, where drops of sweat are easily seen rolling down. The ‘heat regulator,’ or rheostat, is indeed a very important factor, because it enables you to check the heat immediately should a patient feel it more in one part of the body than the other. We therefore constantly watch the patient, and on his giving warning we can still more quickly remove any sensation of burning or stinging than with the rheostat; we merely remove the plug of the conducting wire which leads to the lamp opposite the spot where he complains of caloric hyperæsthesia, which may be on the leg, the thigh, the forearm or upper arm, the soles of the feet, and so on, and on the corresponding, *i.e.*, the right or left, side of the body. This is surely an advantage over all other methods of heat application, and it insures perfect safety in working the apparatus and directing the body with the caloric according to the doctor's and patient's wishes, and with the best results.

“I mentioned also, in a previous part of my paper, that the heat-rays may be partially screened in their course, and I frequently make use of a glass screen of a certain color if the natural color of the luminous light proves too exciting for the patient. Dr. Bowles has told us that the violet end of the spectrum are the rays which produce sunburn, and I have found, as a matter of experience, that the heat produced by red rays is far more soothing and less irritating to many patients than other colors; blue, again, better suits the lymphatic and anæmic constitutions; but those form a specialty of studies, and the more we learn of the pathology of those conditions we are about to treat the more likely we shall be able to decide beforehand which color will be the more suitable for the treatment of any given patient.

“On the whole, I have obtained very good results with our ordinary light-rays for this radiation treatment in cases of neuralgia, headaches, rheumatic pains, and in colds of the head, in dry and cold skin with greatly impaired and difficult diaphoresis accompanied by cold extremities, sometimes pains and stitches in abdomen, flatulence, etc. In cases where the finger or fingers sometimes up to half the hand got cold, bluish, white, numbed, dead, or cribbling, in which treatment with remedies, bath, hot poultices, have not shown the slightest improvement, this luminous electric-heat treatment has produced a very satisfactory change. The same I can say of falling asleep or numbed feeling with formication all over one extremity when lying in bed without compressing the part; this happens mostly in uric-acid diathesis. In such cases massage, open-air exercise, and profuse perspiration by Dowsing's rays abolish the tendency. In old, enfeebled people, in whom the bodily temperature was below the normal before the bath, I have obtained a return to normal temperature by degrees in the course of their baths, and the trouble of cold hands and feet greatly diminished. This, of course, follows the general improvement in the circulation of the blood and the increase of the heart energy.

"One of my patients, a lady nearly seventy-four years old, who came to me in November, 1898, had suffered for eight years great pains in the stomach, having great difficulty in her digestion, combined with nausea and frequently sickness after meals, swelling all around the stomach so that she was obliged to loosen her dresses; the pains are accompanied with great coldness in the stomach and abdomen, extending to the spine between the shoulder-blades, where three dorsal vertebræ, fifth, sixth, and seventh, are very painful on even a slight pressure with the fleshy ends of the fingers. Her whole epigastric region is also very tender on the slightest touch with the hand. The action of the bowels always costive, never diarrhœa or looseness, but sometimes dreadful pains like colic across the whole internal abdomen, returning with great violence every few minutes, and producing cold sweats all over her. Her skin is rather dry and very slow to perspire, even when she tries most persistently to do so during rheumatic pains, which affect both her shoulders down to the elbows, and extend upward through the neck into the occiput. She is not subject to attacks of influenza, but catches violent colds frequently, particularly when travelling; she suffers also greatly from headaches, neuralgia, and during the last two years from great giddiness, and since last year from deafness in the right ear; her strength has greatly diminished; she cannot walk upstairs without great efforts, and cannot walk any distance in the street without fatigue and fear of falling down; bending down is very painful to her in back and loins, and her arms are now very weak, she cannot lift them to the head from painfulness or rheumatism in the shoulder-joints; her legs are frequently taken with cramp, especially in the calves. Her eyes are very weak.

"When I became aware I could not improve her any further I decided to give her a Dowsing bath, which she at once told me has given her more energy and vitality than anything else, and when repeated produced a wonderful change in her, so that at the end of a dozen of these luminous radiant-heat baths, which she took on alternate days with my massage, the deafness and singing in the ear had disappeared, her eyesight improved also. I got a letter to the following effect from her mistress, with whom she was as lady companion for over twenty-five years, being considered rather as an old and intimate friend: 'It is (she wrote) such a comfort to see her (my patient) so well and so cheerful now. Her tale used to be one of constant suffering, and naturally it told on her spirits and nerves. The electric-light baths seem to have had a *great* effect on her, seeming to double the relief your other treatment gave her. The improvement is the more remarkable owing to her advanced age (over seventy-three, I believe) and the fact that her case is such a very chronic one, and, further, because all medical treatment has so utterly failed with her hitherto. All medicines and treatments have hitherto proved actually injurious to her. I was really in *despair*. You will understand, then, how grateful I feel.'

"I have already stated that I find great usefulness in these luminous-heat radiations in combination with massage treatment. I may also say that I can, if necessary, easily use electric-battery currents with these electric sudatorial baths, and I fancy that the open-air treatment for consumption would be greatly benefited by occasionally warming the patient when he is unable to take open-air exercise, because you can charge your patient with as much heat as you find needful for his benefit as well as his comfort. So, if the patient lies on his couch on the open balcony or under the veranda, you merely switch on the current from the main, and he will feel warm without altering his position within five minutes. Let us hope that the authorities of our Hospital will establish a special and separate department for the treatment of disease by modern electricity in all its phases of old and novel usefulness—including constant and interrupted current (hot-water baths) from the main, d'Arsonval's high frequency and high potential currents, the X-rays and lupus treatment, electrolysis and luminous-heat radiation treatment." (JAGIELSKI.)

"In these electric-light radiant-heat baths we have an agent which, while supplying all the advantages of other forms of heat baths, possesses something more; namely, luminous rays affording much of the benefit of sunshine. The principle underlying this form of treatment may be expressed in the fact that *heat facilitates function*. It increases the combustion in the body as evidenced by the increased elimination of carbonic acid from the lungs. The raising of the body temperature depends less upon the amount of heat applied to any small surface than upon the degree to which radiation from the rest of the body is prevented or counteracted; hence, in practice, where constitutional results are desired it is best to give a whole body bath even in the case of local lesions. The effects are very striking and wonderfully uniform. Dr. Chretian, of the Salpêtrière Hospital in Paris, thus states his extensive experience and observations of physiological actions:

"'More or less profuse perspiration not only of the part treated, but over the whole surface of the body.

"'Marked reddening of the skin on the part treated—a capillary dilatation.

"'Diminution and rapid disappearance (sometimes almost immediate) of the pain.

"'Restoration of movement when impaired by pain.

"'Some acceleration of the pulse and increase of the body temperature. The latter may be from one to three degrees, registered by the mouth. It is gradual throughout the treatment, subsides slowly when the heat is discontinued and falls to normal in from three to five hours, if not reduced by after-treatment.'" (KERR.)

"Heat radiation is the propagation through ether of impulses imparted to it from the molecular motion of a heated body. There is not a transference of heat, but a transference of *energy which becomes heat on encountering an obstacle in its path.* Heat and light are each forms of 'radiant energy.' There is no essential physical difference between them, and their laws of propagation are identical. The dark rays differ from the visible rays only in their longer wave-length. Tyndall's experiments show that as light rays are added to a band of the spectrum the heat-rays became more intense, acquire a greater amplitude, and, therefore, a greater energy of vibration, as the latter is proportional to the square of the amplitude. The obvious inference from these facts is that if we desire to penetrate the tissues of the body with warmth we should use luminous heat.

"Now, how does radiant heat effect its curative purpose? Let us present the answer by example. An ankle-joint has been violently twisted, ligaments have been wrenched and some fibres torn across, there has occurred extravasation of blood into the tissues, and perhaps into the joint cavity itself. Considerable swelling has quickly arisen and other symptoms of inflammatory reaction, in which the various structures of the joint are involved—synovial membrane, ligaments, sheaths of tendons, malleolar bursæ, etc. The pain is of a 'sickening' character, and it becomes agony on putting the foot to the ground. There is at first an active dilatation of the arteries and arterioles of the part, widening the capacity of the vessels so that more blood is driven by each heart-beat toward the affected part. The capillary dilatation is less and is chiefly the result of passive stretching by the influx of more blood than they can easily contain, but the result is that the normal difference of tension between the fluid within the capillaries and that in the lymph spaces around them is considerably increased, and hence diffusion of coagulable lymph will ensue. In situations where primary increased flow (impeded and at length arrested by adhering and cohering red and white corpuscles) has been succeeded by stasis the exudation will be still more active. As lymphatic absorption cannot keep pace with vascular exudation the surrounding and uninjured tissues will be highly œdematous and distended with liquor sanguinis which does not coagulate. Much of the pain is due to the pressure of exudates held in by unyielding ligaments. The lymphatic system aims to minimize this evil by increased activity of absorption, but can only in part compensate for the vascular flux. How is heat of service in such a condition? Let us see:

"1. The most obvious result of heat on the exposed part is first a reddening of the surface and next a profuse perspiration. The redness is the dilatation of cutaneous vessels, the result of hyperstimulation. The sweating is due to the dilatation of the network of vessels in intimate relation with the sebaceous and sudoriferous glands and hair follicles, to direct stimulation by the heat of the cellular elements of the glands, and to nerve influence. As the necessary fluid is probably derived from the capillaries by transudation through their walls the blood-pressure within the capillaries will be equalized with the pressure in the adjacent lymphatics and lymph spaces, and this will tend to reduce the cutaneous œdema.

"2. As the result of the above changes in relaxation, pressure, and blood-supply there is a general movement of blood and lymph from the deeper to the more superficial structures of the part.

"3. The now accelerated blood-stream will unload congested parts and carry off morbid products. The lymphatic system, by increased absorptive activity, will lessen to some extent the exudation in and around the joint.

"4. As the penetrating effect of the radiant heat increases the arteries which divide and subdivide in the subcutaneous tissues to supply the cutaneous capillaries will themselves become dilated. The still deeper vessels (the arterioles derived from the nutrient vessels of the joint) will now, in comformity with the law of compensation, have a tendency to contract.

"5. The molecular activity of the part will probably be enhanced, and the metabolic and nutritive process will be for a time accelerated. There may also perhaps occur an alteration in the state of the part, owing to modifications in its molecular constitution, such as might occur from violent perturbation or vibration." (Hedly.)

"In the bath of radiant-heat rays of light the exposure is longer or shorter according as we wish the patient to perspire very freely, as indicated in gout, rheumatism, and all forms of fibrous-tissue adhesions affecting the joints, muscles, etc., or, whether an irritation of the skin with dilatation of its blood-vessels is all that is desired, as in hysteria, neurasthenia, anæmia, etc. The advantage of the electric-light sweat-bath is the fact that it never gives any shock to the patient's system, it does not burden the heart, the production of heat in the organism is regulated. From my own experience I should like to call attention to the favorable influence of the electric-light bath in chlorotic conditions, in neuralgic pains, on the appetite and sleep of neurasthenic patients. For these purposes the warming of the skin without producing great perspiration is all that is required. In all forms of fibrous-tissue adhesions affecting joints, muscle, etc., the slow, vibrating electric current and the introduction of iod. of pot. or cit. of lithium by cataphoresis, after the exposure to the light has proved very beneficial. In cases of gout, rheumatism, Raynaud's disease, scleroderma, psoriasis, the light has proved a most wonderful remedy." (Kreutzberger.)

Reports of the aid of radiant-heat baths in obesity have occasionally been astonishing. "Dr. Strebel gives two of these sweat-baths per week followed by a water-bath of 86° F. reduced for the last five minutes to 64° F., and completes the séance with massage and frictions." While the reduction of excessive local accumulations of fat find a routine prescription in some form of hot air or sweating application the author believes that by far the most energetic *supplementing* therapy is to be found in the tissue-oscillator we describe. Test it but one minute on your own person and you will need no argument about its rationale. Many methods of working off local fat have come to the author's knowledge, but this neat device takes hold of the flabby mass and literally "shakes the life out of it," while the remainder of the system is at passive rest and the patient in a state of perfect comfort. The fact that this adjunct treatment is *delightful* and *short* appeals to most patients as well as to the office practitioner who is in a hurry. Three, five, or eight minutes is a full-length séance for a corpulent abdomen in the oscillator. The results are self-evident after a few séances.

From authentic data we may estimate that not less than 300 sanitariums have procured electric-light-cabinet bath apparatus prior to this date. We have before us a long list of names of high-class institutions using either the Kellogg or Dowsing radiant-heat baths which would impress readers with the spread of photo-therapy did space permit us to cite them. We also have in hand clinical records of cases which lack of space compels us to omit, as this work is mainly designed to teach the practitioner how to do the same work himself. The trend of articles on this subject may be inferred from a few lines taken from an extensive account of cases in a London hospital:

"Many more diseased conditions than might at first sight be imagined are benefited by local radiant heat. My rule at the hospital for some years has been when a patient suffering from any complaint does not improve after a course of routine drug treatment to order radiant heat, and I must say that in the majority of cases improvement very quickly shows itself, often to a marked degree. The following cases are notes from a large number of diseases treated by myself at the Northwest London Hospital."

The list of cases described covers rheumatoid arthritis, vasomotor disease, epilepsy, chronic rheumatism, chronic Brights, asthma, bronchitis, chorea, peripheral neuritis, spinal disease, post-fracture of shoulder, strumous ulcers of leg, etc., some of them having only three or five treatments. The writer proceeds: "In addition to the above, if space permitted, could be cited as having been successfully treated by radiant heat all forms of arthritis—rheumatic, gouty, neurotic, tubercular, traumatic—also synovitis, bursitis, periostitis, adhesions, hysterical joints, various forms of neuritis, paralyses, cases of general or local malnutrition, many skin diseases, etc." Evidence of the value of luminous heat needs as little further discussion as does the value of food and sunshine.

In an extensive review of "The Progress of Therapeutics," during

1900, Wilcox disposes of X-rays in nine lines, with mention of their use by one physician and in two diseases, but accords the following longer notice to the fellow product of electricity—the radiant-heat rays, which we may almost call dark X-rays. Many times a writer applauds one product of electricity while ignorantly rejecting its twin brother, and *in these days when similarity of action can be traced through many apparently variant therapeutics a broad study of the so-called physical agents will teach us that they group round very similar indications and work for good along very closely related lines. An expert can duplicate average effects of almost any one of them by skilful direction of a dozen others. The force of this fact has been impressed upon the author during his investigations for this book, although he was well aware of it before.* But to quote:

"Various authors—Paulson, Rand, Gomberg—have studied the electric-light bath. They find that it is the most satisfactory and efficient of all methods for inducing perspiration, inasmuch as it is a direct stimulant to the glands. Perspiration appears in from three to five minutes, even when the temperature of the air surrounding the patient is not above 85° F. That this bath is a powerful means of calorification is shown by the fact that the rectal temperature may rise to 103° F. or even higher in the bath. The peculiar value of the electric-light bath is due to its efficiency as a source of radiant energy which is not communicated to the skin by convection, for the skin as well as the air is to a large extent transparent to radiant heat, and the same is true of all the living tissues. Thus it is true that the heat from the electric-light penetrates the body just as it would penetrate any other transparent or semi-transparent medium.

"This bath has also the advantage that it encourages heat elimination by promoting free perspiration. There is also the excretion of effete matters which accompanies free perspiration, and with the elevated temperature of the blood there is a quickening of all the vital processes. It is claimed that this method is especially valuable in the treatment of cardiac disease and in diabetes where prolonged sweating measures cannot be employed without more or less risk. The penetrating nature of the heat of the electric-light bath stimulates oxidation of the residual tissues, and this hastens the disappearance of the redundant fat in obesity. In the dropsy associated with either cardiac or renal disease, in the toxæmias of chronic dyspepsia, in chronic malaria, syphilis, chronic rheumatic affections, anæmia, and in various other disorders excellent results have been achieved. A local application for fifteen or twenty minutes, followed by the application of an ice compress, is almost a panacea for the pain of sciatica. Since it is evidently a nerve tonic, the excellent results of its use in the treatment of the symptom-complex known as neurasthenia, particularly when due to toxæmia, rest on a solid foundation." (Wilcox.)

Educated medical men making inquiry as to the principles of photo-therapy may wisely distinguish between the findings of scientific research and the remarks of illiterate attendants employed to keep the apparatus in order and wait on patients. This is not always done. A nurse recently showed the author a radiant-heat apparatus and glibly stated: "Yes, we have baked a good many patients. All there is to it is the heat, you know. Some use gas and this uses electricity. That is all the difference." But between this sapience and science there is a gap that physicians should not fill in with credulity. Yet despite the fact that the physiology and therapeutics of light-rays are now demonstrated with greater fulness and accuracy than those of ninety out of a hundred drugs the facts still lack diffusion throughout the profession. This was illustrated in a most interesting letter from Carlsbad, published in 1901, in which Dr. James Tyson gave an account of his late visit:

"The electric-light bath is an interesting bath. It consists of a cabinet in which the patient is inclosed except his head. Numerous lights project from the sides of the cabinet toward the interior. The bath is a sweat-bath in which the heat is derived from the electric lights, and the chief feature is that the sweating takes place at a much lower temperature than that in a vapor- or hot-air bath. My recollection is that it is about 95 F. None of the physicians with whom I conversed at the Kaiserbad *were able to offer any explanation.*"

In a similar manner every department of therapeutics suffers from statements that "nothing is known" about action, rationale, etc., while *the fact is that we are here able to present definite instruction from many sources*, explaining the rationale of the electric-light bath in each of its varieties. The important difference between Hot-air Therapy as taught in our section on that subject and the action of luminous heat-rays is maintained by all writers on photo-therapy, and "radiant heat" is not "hot-air" by any means. We shall now study the scientific investigations of Dr. Guyénot of Aix-les-Bains respecting radiant heat in the years 1900-1901.

"Sunlight is the great type of luminous radiance which warms bodies on which its rays fall. The heat of the sun is not 'conducted to us through a warmed ether 95,000,000 miles thick, but is 'radiated' to us through cold space and generates warmth on the earth by the potential energy of its impinging rays. Furnace heat is different. Mechanical devices (lamps in vacua) can transform electrical energy into radiant-heat luminosity. Some bodies completely stop the passage of heat-rays and some stop light-rays. The first class are called 'Athermanous' and the second 'opaque.' Some transmit heat-rays and are called 'Diathermanous,' while bodies diaphanous to light-rays are

PLATE 237.—The Dowsing Electric-Light Radiant-Heat Apparatus. This illustration shows two reflectors on each side arranged on an ordinary bed with patient ready to be covered. The apparatus does not lend itself well to photographic display, and unless one has seen the original the cut gives a poor idea of the treatment. Such an apparatus is now in use in New York. The text aims to supply the essential instruction.

PLATE 238.—Local applications of single units of the Dowsing Radiant-Heat Light Rays. After a recent publication in Paris.

called ‘transparent.’ An alum solution will stop heat-rays while it passes light, and a piece of smoked rock salt will shut out all light, but will let heat-rays pass freely.

“The transmission of conducted (ordinary) heat depends on heating the surrounding air.* To raise the temperature of any substance fifty degrees by heat conducted through a separating layer of air it is absolutely necessary to raise the air fifty degrees. Radiant luminous heat will give the same result without heating the air. Luminous heat radiates across space; it can be diffused as light; it can equally be reflected, and directed by reflectors. A piece of tinder can be fired by reflected radiant heat twenty feet from the light, as if it had been in contact with the flame. Sunburn takes place on the Alps with the air freezing. Radiant luminous heat results from the blending together of heat-rays, luminous-rays, and chemical-rays, and it is possible to alter the proportions of these by mechanical devices, or to eliminate any one of them and have separately either heat, luminosity, or chemical action. Therefore, concentrating a hundred pages of scientific experimental research into a few words we may summarize the clinical facts thus:

“Radiant Luminous Heat is composed of rays of the spectrum which can be separated from each other for selected actions.

“It can be reflected by mirrors or polished metals, as can rays of light.

“It can pass through glass without losing its properties.

“Radiant heat can be directed on a body without heating the surrounding air.

“By special apparatus it can be diffused and caused to heat the air to very high temperatures, and can not only treat patients in this way, but can warm rooms as well as the familiar gas-heater but with the advantage that electric-light radiators do not vitiate the atmosphere we breathe in.

“The physiological action of radiating luminant heat is a composite study of three mingled groups of rays—the low-red spectrum, the visible spectrum, and the ultra-violet spectrum, each possessing important properties and supplementary effects. The first remarkable fact to notice is that the human body can comfortably support higher temperatures with radiant heat than with conducted heat. The general body application is practicable up to 400° F., while local applications may reach 500° F. with safety. Treatment employs a dosage below these maximums, but the patient can tolerate these for forty minutes without harm. Radiant heat has a much greater power of penetration than conducted heat. The pulse is excited less than in Turkish-baths, and in an hour returns to normal and becomes stronger than before. Profuse perspiration is induced, varying in amount in different persons, but always more abundant than in other baths.

“The sedative action of the radiant-heat bath is most marked.

* In this section all references to “common heat” will mean conducted heat as distinguished from radiant heat. Some authors call conducted heat “obscure heat,” or “dark heat,” in contrast with luminous heat. Keep the difference in mind.

In cases of gout and suitable painful affections a sense of relief is experienced almost from the first. Among other tests, a dog was treated with a bath of conducted heat at 150° C. At the close of the application the elevation of the body temperature was 1 degree and of the legs 3.6 degrees. In a radiant-heat bath several days later, at 122 degrees C., the active effects were about doubled, the body temperature rising 1.8 degrees and the hind legs 8.3 degrees centigrade.

" We will now consider a particular apparatus which is constructed to especially develop luminous heat in far greater quantities than the commercial reading incandescent lamp. It was sent to me from London with a request to investigate and report on its action. By means of special filaments and vacuum tubes the lamps of the apparatus emit very intense heat-rays with less chemical radiation than arc-light or the sun. After witnessing and demonstrating the results obtained I submit the following to the French medical body, being absolutely convinced that those who will study as I have done will soon share my opinion as to the therapeutical benefits of this apparatus. It is needless to expect impossibilities of it, but we have here a new and powerful ally which is without danger, and which leaves far behind all other bath systems of hot-air. The heat-rays are of such intensity that a thermometer placed between two lamps sixteen inches apart and provided with reflectors will almost immediately rise to 400° F. The dosage is regulated by a rheostat. The physiological actions of this form of radiant-heat bath consist in the following phenomena:

" Very marked redness of the skin. Very abundant perspiration and the elimination of increased quantities of carbonic acid by the lungs. Rise of pulse and temperature. Increased excretion of urea and solids in the urine and lessened uric acid. Increased activity of general nutrition and elimination. Much greater penetration than conducted heat. Excitation of the skin by the chemical rays. Increase in number of red blood-globules. In all cases the degree and extent of action varies according to the number of lamps and duration of treatment. On such diseases as gout, rheumatism, arthritis, and other kindred diseases the effects observed are: A short time after placing the part in the apparatus the skin becomes red and perspires freely. The redness is due to the dilatation of the superficial capillaries and the perspiration is the sequence of three factors:

" 1. The dilatation of the vessels, particularly those in close relation to the sweat glands, sebaceous glands, and follicles.

" 2. The direct stimulation of the cellular elements and of the glands by various radiations.

" 3. The reflex excitation of the nerves.

" The dilatation of the cutaneous vessels and the necessity for the tissues to replace the moisture lost by perspiration leads to a general movement of the blood and produces an increased circulation. This lowers the blood pressure and removes the principle cause of painful symptoms, and at the same time carries away the morbid products in the circulation. At this moment, under the penetrating and prolonged action of the radiant heat, the arteries dilate and then contract according to the well-known laws of compensation. This takes place without danger to the patient, and the presence of luminous and chemical rays add complex factors of benefit which are of incontestable utility.

"All affections for which dry hot-air is useful, whether local or general, are treated with great advantage in the improved form of radiant-heat bath. Physiological data and clinical observations are now so numerously demonstrated that in certain affections we have established precise indications and obtain particularly good results. Among these are gout, rheumatism, rheumatoid arthritis, phlebitis, contusions, sprains and fractures, obesity, anæmia, exudates, coldness, recent 'colds,' and to a less extent, sciatica, neuralgias, nephritis, nervous diseases, diseases of the lungs, skin, and various unclassified conditions of both functions and organs.

"*Gout.*—One treatment in the apparatus employed by me often suffices to give relief. The sedative effect is felt at about 320° F. and is continued several hours after a bath of thirty to forty-five minutes duration, and if the pain returns it is always less severe than before. The duration of a severe attack can be reduced to a few days by giving a *general* bath in the morning and a *local* bath to the affected joints in the afternoon. In chronic gout the pain is slowly but surely lessened and beneficial results obtained. Adjunct treatment to meet special indications will hasten the results.

"*Rheumatism.*—In chronic cases, articular, muscular, gonorrhœal, and in senile arthritis, the sedative action of the baths is marked after a course of treatment. We have also treated a case of inflammatory polyarthritis in which salicylate and antipyrine failed to relieve. A complete bath at 320° F. for twenty minutes daily gave great satisfaction and benefit. The pain diminished, the swellings decreased, the temperature lowered, and the urine increased. Relief followed each application, and the attack was limited to twelve days with a good convalescence thereafter.

"In *Contusions*, *Sprains*, and *Fractures* radiant heat renders great service and in many institutions has become the routine remedy.

"In *Phlebitis* a single treatment produces a marked decrease in the size of the affected part, and by repeated applications a rapid return to normal is accomplished.

"*Rheumatoid Arthritis.*—In recent cases, even at the period of very sharp attacks, the joints are rapidly relieved and reduced in size by the treatment. In later stages with ankylosed and deformed joints with little pain the immediate effect of radiant-heat applications is not marked, but with perseverance an improved nutrition is established and final results become gratifying.

"The value of radiant heat in *nephritis* consists in the abundant diaphoresis which it causes and the relief to the kidneys and heart. In many general affections radiant heat is an excellent auxiliary to other measures, and will often enable other measures to succeed when they have failed alone."

"It is the usual rule that the best effects are obtained by applications to *large* surfaces even in local lesions, and the general body apparatus is therefore mostly employed not only for general conditions, but for localized affections. In the latter case the full bath is applied to all except the head, and at the same time a special reflector is used to intensify the rays on the local tissues needing concentrated local action. The apparatus permits this to easily be done."

Studies in Hot-Air Therapy

"*I originally approached the invention with the scepticism which becomes second nature to medical men. But having tested it on my own person I found that it did what it pretended to do.*" (SHADWELL.)

CHAPTER XLVIII

HOT-AIR THERAPY

Study of Actions and Effects. By-Effects. Care of the Patient During Hot-Air Treatment. Accessories to Apparatus. Directions for Use. The Body Machine. Full Technic. Leg and Arm Machine. Study of Mistakes and Failures. Clinical Experience. Diagnosis of Pus. Hot-Air Apparatus for Use in Bed.

Wightman's conclusions about hot air as a therapeutic agent were as follows:

Dry heat is a valuable pain-reliever without any of the depressant effects common to drugs.

In connection with constitutional and medicinal treatment we have in dry heat a positive curative agent.

It is a stimulant to rapid repair and absorption.

It is one of the most valuable eliminative agents we possess.

Where indicated, it possesses a sedative action on the nervous system obtained by no other means.

Let us now study the agent of which so many have made use. As the therapeutic effects of heat depend on definite dosage to meet indications and require a form of administration suited to the case, a special apparatus may enable us to secure effects which surpass those generally obtainable. When, therefore, we leave the consideration of common heat and study the therapeutics of heat of very high degrees kept *dry* by systematic precautions, we at once enter regions of technic across which his familiar knowledge of hot-water bottles, hot douches, hot-air cabinets, Turkish and Russian baths, hot fomentations, heated flannels and bricks, etc., will not carry the practitioner with success. A new study must be made of actions, indications, contra-indications, and technics. In this section of this work we shall cover the principles of modern scientific Thermæro-therapy. That it is an important medical subject is evident from the growth of the manufacture of varied and ingenious apparatus.

To cite cases, medical reports, and discussions of theory and practice relating to superheated dry air could interest us through many pages. With ease we could devote an entire treatise to the subject, but to keep this section to its main purpose of *Instruction in Technique* (which no regular treatise now supplies) we must omit routine text and study how best to create for ourselves the good results that others have described in recent literature. We venture just one preliminary word. Says Dr. Shadwell, in undertaking the supervision of "Authoritative Reports" on this therapy in gout, rheumatism, arthritis, sprains, sciatica, eczema, etc. (a notable English work published in 1898):

"When requested to supervise the preparation of this volume I readily consented for three reasons. In the first place experience has convinced me of the value of the treatment; in the second place, I think it ought to be better known than it is; and, in the third, I have no personal interest in it whatever. I originally approached the invention with the scepticism which becomes second nature to medical men, but having tested it on my own person I found that it did what it pretended to do. And then I saw a boy with a knee-joint full of fluid and wincing at every movement gradually charmed off within half an hour into a smiling and painless indifference which permitted the free handling and flexion of the limb without a murmur. Since then I have seen results produced in old and hopeless cases of rheumatic arthritis which I could not have believed on lesser evidence than my own eyesight. The facts related in this volume amply corroborate my experience and make it unnecessary for me to say more on that head. Attested as they are by many independent observers of high standing in the profession, they form a body of evidence which no one can affect to ignore or despise. They do not come from a few clinics, but from a large number of first-rate hospitals, not only in England, but in Paris, Canada, and the United States. It is impossible to deny the weight of so large a mass of concurrent testimony."

Leaving all other narrative to the reader's leisure in his library, let us at once begin our practical study of what dry hot air can do and how we can make it do it.

Studies of Actions and Effects.—What is now popularly known as hot-air treatment means the application of dry air heated to temperatures ranging from 200 to above 400 degrees Fahrenheit, with the tissues protected by ventilation and by absorbent coverings which remove the diaphoresis of the skin and maintain the essential factor of safety—dryness during the exposure. To be of active therapeutic value the temperature must be from 220° to 280° F. for the whole body (save the head, which is never placed in the apparatus), or 300° to 380° F. or upward for local applications. Cork, wood, asbestos, fibrous magnesia mattresses, stout canvas—poor conductors of heat—line all parts of fine machines which the patient is liable to touch, and permit a dosage far higher than former means of thermal therapeutics. Moderate degrees of heat in any form do not parallel the actions of high intensities, and are not to be compared with the therapeutics of special hot-air apparatus. Let us now note the central facts which the physician needs to know.

When any part of the body is subjected to the action of *currents* of superheated dry air in the manner we are here considering, it speedily becomes hyperæmic. An initial contraction of the arterioles and capillaries is followed in a few moments by a dilatation which causes a deep flush to spread over the whole surface. The pulse becomes fuller and stronger, and increases from ten to twenty-five beats per minute. In favorable cases a sensation of agreeable anæsthesia is induced, and pains of types which are relieved by heat diminish or are entirely removed. Muscular spasms relax, a profuse acid perspiration with increased specific gravity ensues, and with the stimulation of the cutaneous nerves and lymphatic circulation the patient feels a sense of general comfort. If this state is not developed, but on the contrary pain or some symptomatic disturbance is aggravated, then alter the dosage as indicated or consider if the indications have been misunderstood. A patient on whom the effect *appears to be unfavorable* can be made a most useful source of clinical study, and by improving opportunities to question the causes of non-effects or ill-effects when these unexpectedly occur we can learn how to do better next time.

With the *body* apparatus the increase of temperature may be from one to five degrees by the mouth, the rectal reading being slightly less. This low rise in general temperature of a body subjected to nearly 200 degrees above the normal is maintained by the safeguarding evaporation of water from the skin, and if this is interfered with a blister or burn may result and severe effects may occasionally develop.

The alkalinity of the blood is increased, and there is a temporary increase in the number of corpuscles. Respiratory movements are increased from two to six per minute. The action of this intense heat tends to loosen small stiff joints, reduces œdematous swellings, creates marked acidity of the sputum in rheumatic and gouty cases, sets up a slight thirst and a varying loss in weight. The renal secretion is stimulated as to amount of water, chlorides, and urea, indicating a marked increase in metabolism. The urine passed immediately after treatment has a decreased specific gravity.

The primary action during exposure to the heat will be followed after several treatments by *physiological* effects, among which are:

increased tone and functional activity of the circulatory apparatus and excretory organs; increased excretion of uric acid in lithæmic cases; disappearance of acne in gouty cases; temporary increase of soreness and nervousness in gouty and rheumatic cases during the absorption of urates and other deposits from the tissues; the softening and absorption of deposits, callus, exudates, fibrous adhesions, etc. In cardiac and renal cases there is a reduction and sometimes permanent relief of albuminuria. Many chronic skin diseases witness a great improvement. The inflammatory reaction following a severe sprain or the breaking up of an ankylosed joint is limited (and sometimes aborted) by immediate treatment. There is generally a little reduction of weight in ordinary patients and a greater reduction in cases of obesity, and while this may be temporary, yet when the object of treatment is loss of weight the results can be fairly maintained as a rule by a suitable diet and an occasional hot-air séance after a course of fifteen to twenty primary treatments.

Congested mucous membranes and kidneys, and throbbing headaches are relieved by the revulsive action on the vascular surface, and Kessler cites a case of angina pectoris; a woman who would submit to 240 degrees for an hour in a body machine with entire relief to her attacks, though she would faint in an ordinary hot-air cabinet. Some remark a soothing influence of the heat with a tendency to sleep. Without doubt one of the most important therapeutic factors in hot-air treatment is *the increased flow of temporarily superheated blood through the tissues.*

By-effects.—When a chronic case is subjected to frequent treatment for a long period (an hour and a half) there may be a debilitating action on the system and the patient may complain of being weakened. Intermit the séances for a time or maintain a tonic state of the tissues in all such cases by the auxiliary aid of static electricity. The value of skilfully employed static electricity as an adjunct to both Thermæro-therapy and Hydro-therapy is very similar to that of drink as an adjunct to food.

When too long a treatment is given to susceptible patients they may complain of nervous restlessness and even muscular twitching, and these call for attention on the part of the operator. Do not exceed the time of benefit in any séance.

If a patient finds the routine drink of cold water to cause palpitation of the heart or distress of the stomach try a hot drink to aid the perspiration, or let the drink if desired be taken at the close of the séance. Individualize the matter of drink during hot-air treatment and consult idiosyncracies rather than a routine.

If a patient does not develop profuse sweat as the heat rises at the first treatment a *low* temperature will cause distress. A few people "never sweat" or sweat with difficulty, and these cases must be watched till the function is established under a gradual course of preparation. Soften the skin with manipulation and unguent, stimulate the glands by motor-massage if you have that useful adjunct, and lift the heat slowly to tolerance for four or five preparatory treatments, when perspiration will usually be all that is desired. Without the safety-valve of active sweat glands 160 degrees of heat will be more of an over-dose than would 300 under right conditions. Watch this point.

In some cases of rheumatic, gouty, or neurasthenic patients miliary rashes may be caused by very acid perspiration, but these disappear in a few days as the sweat becomes neutral and finally slightly alkaline in reaction. Slight epistaxis has been noted in a rare case. Local cyanosis and chromidrosis have (rarely) been noticed as incidents during first séances, but have disappeared speedily. In a case of a neurotic young woman with an irregular heart the pulse went below fifty after each séance, but this was temporary and no other symptom was noticed. A patient may feel a sense of lightness in the head or see flashes of light before the eyes at the beginning of a first treatment, but these speedily cease or will be avoided by a little caution in developing the dosage slowly. Operators have reported that they have treated advanced cases of general arterial sclerosis without any unpleasant effects from increased blood-pressure. In these cases caution is wise. Develop the dose gradually.

"Since my former article," says Blech, "I have treated over 200 patients with the hot-air apparatus, making a total of 3,621 treatments, without any ill-effects other than slight superficial burns of the epidermis which could have been avoided had both nurse and patient exercised the necessary care. I make this statement as an offset to a reported case of an old man in whom was said to have been observed acute parenchymatous nephritis and uræmic intoxication as the result of hot-air administrations. The case was one of subacute rheumatic synovitis. The urine was examined three months before the use of hot air began. The symptoms persisted for thirteen days after hot air was stopped, despite active rational treatment directed to the nephritis. If due to hot air the symptoms would have ceased in two or three days. The report by no means proves that the condition was caused by hot air. It may, however, have been caused by a sudden chilling after heating the extremity treated and indirectly thus heating the body. I have directed dry hot air at a temperature of 400 degrees for one hour daily against the lumbar region in two cases of acute parenchymatous nephritis, and in both instances with increased tone and functional activity of the circulatory apparatus and excretory organs; increased excretion of uric acid in lithæmic cases; disappearance of acne in gouty cases; temporary increase of soreness and nervousness in gouty and rheumatic cases during the absorption of urates and other deposits from the tissues; the softening and absorption of deposits, callus, exudates, fibrous adhesions, etc. In cardiac and renal cases there is a reduction and sometimes permanent relief of albuminuria. Many chronic skin diseases witness a great improvement. The inflammatory reaction following a severe sprain or the breaking up of an ankylosed joint is limited (and sometimes aborted) by immediate treatment. There is generally a little reduction of weight in ordinary patients and a greater reduction in cases of obesity, and while this may be temporary, yet when the object of treatment is loss of weight the results can be fairly maintained as a rule by a suitable diet and an occasional hot-air séance after a course of fifteen to twenty primary treatments.

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"In the beginning of my experiments I was inclined to be afraid of intense heat and examined every patient's heart, arteries, and kidneys before prescribing hot-air treatment. In a certain class of heart disease an indiscriminate application of hot air might perhaps lead to disastrous results and I have myself observed a few persons faint, but immediate cessation of the treatment, a cold drink, and a cold wet towel around the head suffice to restore the patient. Patients with valvular insufficiency have taken these treatments for articular affections and have tolerated them well, beginning with short applications of lower temperatures and developing the dosage gradually."

This is sufficient to guide the physician in the matter of intrinsic actions, and we will next consider the particular attention to be given the patient. We shall see that this depends much on the part treated, and is most important when the whole body save the head is subjected to a high temperature for forty minutes.

Care of Patient During Hot-Air Treatment.—Undoubtedly proper care of the head is one of the most important functions of the attendant during any general hot-air séance which acts on the cerebral circulation. Test this yourself so that its necessity will be best appreciated. Even without any of the new apparatus go into an ordinary Turkish or Russian bath; let the head be dry; let it get hot; feel the general discomfort that will tend to develop—in some at lower temperature than in others, but finally in all. Even nausea, vertigo, and dyspnœa may appear, as well as congestion and headache. Then without lowering the body-heat at all or reducing the temperature of the room note how a cold wet towel to the vertex and around the head clears away the symptoms and produces comfort. Much more is there need of care of the head when the highest effects of modern Thermæro-therapy are sought.

Under extreme systemic dosage it is not enough to simply apply dry cold to the head. There should be a *radiation* of the heat; the application to the head must be moist to assist radiation and must not only be applied at the start, but must be continually renewed as needed throughout the séance. The dexterity with which the attendant cares for the head will have much to do with the future visits of the patient and the satisfaction of the treatment. The patient should not only be benefited, but he should be benefited with *comfort*. The best teacher on this point is the instruction of personal tests. Make them on yourself and give the benefit to your patients. They will appreciate it.

With the body apparatus the preparation of the patient and the

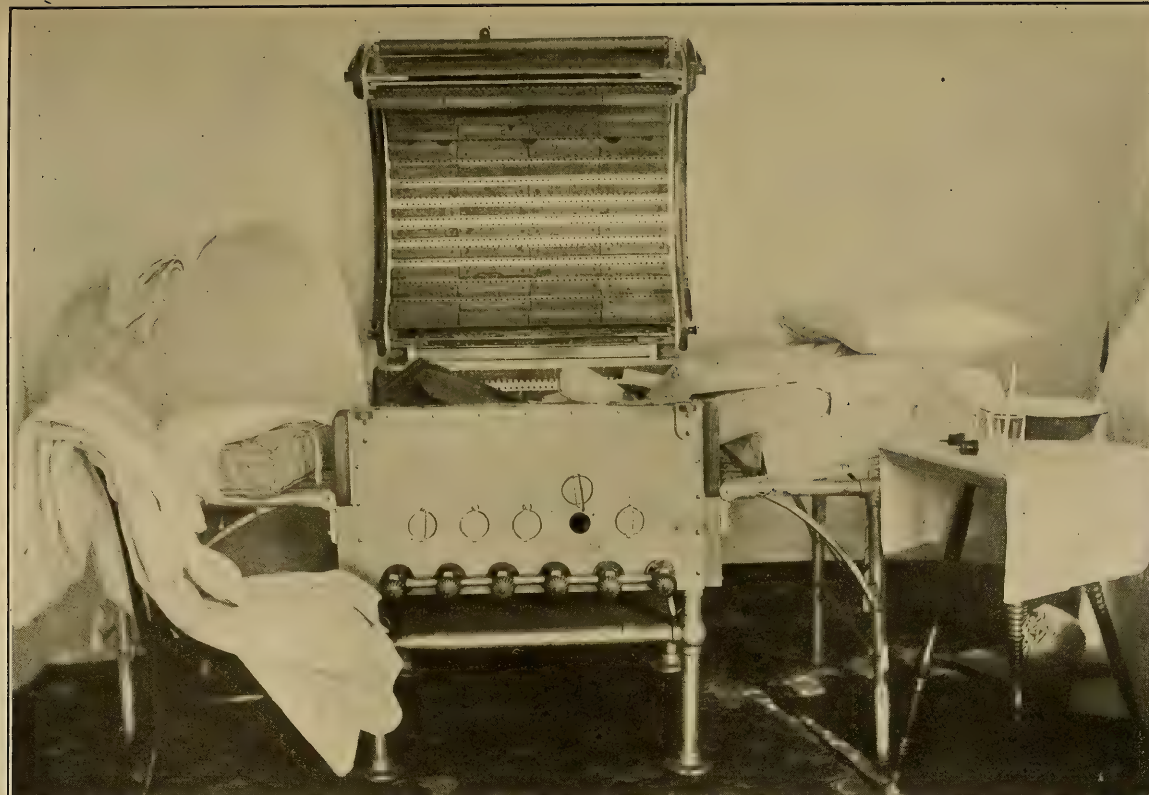

Plate 239.—Sprague Body Apparatus (open) showing details of complete equipment.

The series of sixteen Instruction Plates on Hot-Air technics immediately following were photographed exclusively for this system of instruction, and represent the methods of the Sprague Hospital.

Plate 240.—Patient in position for treatment and apparatus being closed by attendant.

PLATE 241.—Sprague Body Apparatus closed and patient taking drink through tube.

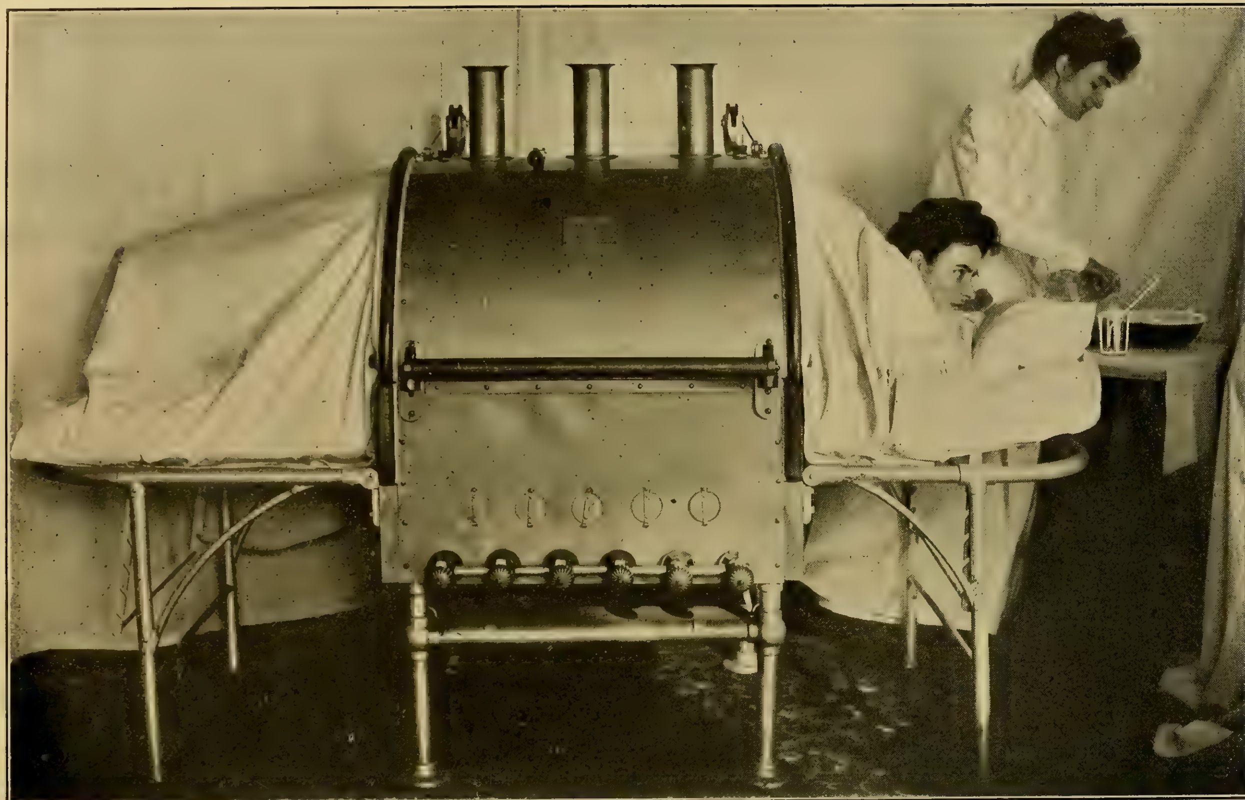

Plate 242.—Showing patient turned in body apparatus and application to entire back.

precautions to observe are very important. Judgment in the matter of covering must be acquired by experience. What would be too light for some will be too heavy for others. If the covering is too thin the heat may "burn," and if too thick the object is defeated. New patients in the leg apparatus complain first and most of the feet. The extremities should be carefully watched. Too much covering may prevent rather than aid perspiration. With ordinary precautions there is no good excuse for burning a patient.

During the first treatment the patient should have constant attention. Watch the respiration and pulse as well as the thermometer on the apparatus. Always exercise care in a patient's first treatment to overcome timidity and the natural dread of an untried high temperature. Begin within comfort and increase the therapeutic dosage with care, and very slowly, till reactions are determined and benefit is established. Then the same patient may be treated confidently.

As the dosage of heat depends on the condition of the patient and the disease, as well as on the extent of tissues to be heated, the difference between small local applications and the general treatment in the body apparatus must be adjusted to the case. While intensity ranges from 120 to 400 degrees the extremes relate chiefly to local application to small parts. With the general surface of the body subjected to a heat which acts upon the heart, lungs, kidneys, great blood-vessels, and nerve centres, a temperature of more than 280 degrees is seldom used. Do not hastily get the idea that hot air always means 400° F. Probably the majority of treatments are under 350 degrees. Profuse perspiration is obtained usually at 180° F.

A séance in the body apparatus is quite a different thing from a limited local application to an extremity or small joint. Fifteen minutes of *general high-intensity heat* is often enough, and thirty minutes is a fair average limit. The time depends on the conditions. General treatments of an hour should be given only to meet definite indications in a special case. Local applications are more often higher in dosage and longer in time. Full hour séances are often beneficial here. Regulate dosage and time by the effects. Individualize according to results. Judge the indications and make a first cautious treatment to nearly meet them. Then modify the next treatment by the report of the effects of the first. Bear in mind that the entire time spent in the machine is not all *active* treatment, hence do not consider that the body has forty minutes of maximum dosage. With the slow and gradual rise of temperature which should be taking place from the beginning to nearly the end of each séance the period of *high-intensity* dosage is comparatively short.

In order to care for the patient certain accessories besides the main machines are needed, and after stating what these are we will be ready for the explicit clinical directions which form our main concern.

Hot-Air Accessories.—Besides the chief apparatus, hot-air treatment requires a few minor but very necessary adjuncts, and among these are:

1. Light-weight bath-robes for men and women patients. Have the robe laundried after use and serve each patient with a fresh robe folded so as to be unmistakably direct from the laundry.

2. Have a pair of bath slippers for the patient to slip on after taking off his own shoes and stockings. Washable ones are easily kept clean, and that is a recommendation with many patients. They are needed in walking to and from the place of undressing to the machine, but are not kept on during treatment in the hot air.

3. A liberal supply of light turkish towelling of assorted sizes is needed. Have some in sheets the full length of the patient. Have some in regular ordinary towel sizes. Also small squares like a "wash-rag." Also rolls of absorbent cotton.

4. A massage table of suitable height and equipped with sheet, blanket, and at least four medium-sized pillows is wanted. Take an ordinary hair or feather pillow and over it put a cover of white rubber sheeting to make it waterproof in its uses when damp cloths are placed under a patient's head. Outside this rubber covering use a clean muslin pillow-slip as on any other pillow. An abundant supply is important, as some patients want the head low and one or two will adjust it right. Others want the head higher, and by adding one or two more the patient can be easily suited. Also, during massage of the abdomen the head will be raised on extra pillows and the knees flexed to relax the muscles.

5. A supply of alcohol is needed. The alcohol-rub is a routine which many patients value highly. Get two of the narrow-necked bottles with special stoppers such as barbers use to dash shampoo solution on the hair. Keep the clear alcohol (for rubbing) in one bottle near the massage table. In the other put a cleansing mixture made by adding one part of saponis viridis to two parts of alcohol so as to form a liquid that looks like sherry wine.

For the sponging-off process have a neat *papier-maché* or enamelled pail holding about a gallon. For each patient put in this pail about two quarts of warm water and a dram of the above soap solution. Have a soft large sponge, and when beginning on a patient squeeze it out a few times in the fresh water and a fine cleansing lather will form. This removes the effects of perspiration from the skin in a most agreeable manner and leaves the skin velvety. Do not use plain warm water or ordinary soap. Make up a little stock of the above mixture and fill the shampoo bottle as needed.

6. A neat basin for the cold-water compress to the head while the patient is in the cylinder must be near the machine. Also the drinking glass and tube, or patent straw. A patient cannot well use his hands to drink directly from a tumbler when recumbent in the apparatus, and a tube to suck through is essential. A fresh patent straw for each patient will be appreciated by those who are not sure that a tube of glass is really aseptic and clean since the previous case. Ice for the drinking water will be needed, and in summer the water for the compresses will need ice to cool it sufficiently. Where good water exists use the regular supply, but in some localities the better class of patients will appreciate the attention of a special carafe of some fine table-water instead of the public storage. Lithia may be added when desired.

In winter extra blankets will be needed to cover over patients while resting, but in institutions with systematic facilities the temperature of the dressing- and treatment-rooms is kept at an even degree the year round, except as it rises higher in summer. In the treatment of women patients who want to avoid dampening any part of their hair a fine silk bathing-cap can be used while wet cloths are applied to the forehead and back of the neck. Do not use an ice-bag on the head as a means of keeping it cool. Continuous cold of this kind is not wanted in these treatments, and the reaction after the séance when ice-bags have been used has been unpleasant in some cases. The cool, damp cloths, used as here taught, are far better than an ice-cap, as a rule.

Large institutions will have several machines and rooms in use for a large clientele, but in smaller practice two medium-sized rooms will do. Have the machines in one room and move the patient to the other for the after-treatment and cooling, and a second case can be progressing in the machine while the first is cooling off. For local machines less space is required, and with duplicate apparatus several cases can be cared for in rapid succession.

Some will ask what assistance is needed. The chief demands arise from the use of the body apparatus. Male assistants for male patients and female assistants for female patients is the rule in institutions using this therapy. Were it not for the sponging and massage this would be less necessary, for during the hot-air séance there need be no real exposure of the patient. In most local hot-air applications one attendant could serve both sexes without difficulty. Our Instruction Plates show how little objection there need be to this.

Attendants are recruited from among graduates in massage. They need have no previous experience with thermæro-therapy, for you can speedily direct them in the mechanical details, all medical responsibility resting with the physician. Owing to the multitude of massage operators of both sexes it would appear that satisfactory attendants could be readily obtained anywhere in this country. When only a local apparatus is used for an occasional case in private practice it is perfectly feasible to get along without any assistance at all. Any new assistant or physician with the following directions in his hand may confidently master the technic we shall now study.

Directions for Use.*—In important respects the technic of the *body* apparatus differs from that of the more local application in the leg and arm apparatus; hence we shall here separate instruction covering details of managing the patient during both general and local séances.

The Body Apparatus.—It takes about ten minutes for the large machine to warm up. Therefore light it ten minutes before the patient is ready. The gas heater works exactly like a gas range. Use a match or wax taper; turn on the gas full, wait an instant till gas fills the tube and drives out the air, hold the lighted taper near enough to the burner to ignite, and observe the effect. If (as often happens to a beginner who has not yet acquired the knack) the gas blows back with a report and burns with a yellow flame at the ventilator, turn on the gas at once, as it has not properly lighted. This happens chiefly when the cold pipes are first used after standing over night. When once warmed by the flame the gas flows in and mixes properly with the air and burns with the familiar blue jet, which is correct. Relight the burner till the flame is blue. The blue jet is free from the poisonous vapors of the yellow luminous flame and gives out far more heat. A flame, the color of the gas-light we read by, would be all wrong for the burner in a hot-air machine. We want heat, not light, and the blue flame which suits the heater would be useless to read by. This preliminary item is important.

Light the body machine with its extensions off. Take out the thermometers. Close up the ends with the canvas curtains drawn over the thermometer-holes in the top and close the ventilating funnels. This shuts off escape of heat and enables the apparatus to warm up quickly for use. Meanwhile have the patient undress completely and

* The author desires it to be understood that owing to the many different designs of apparatus certain details in these instructions must be adapted by each operator to his own machine. Explicit directions based on a given instrument cannot include every detail of other designs, but the *principles* involved are essentially those here taught. Nothing in this work is intended to discriminate against any apparatus not illustrated in our Instruction Plates, which cannot picture every machine in the market.

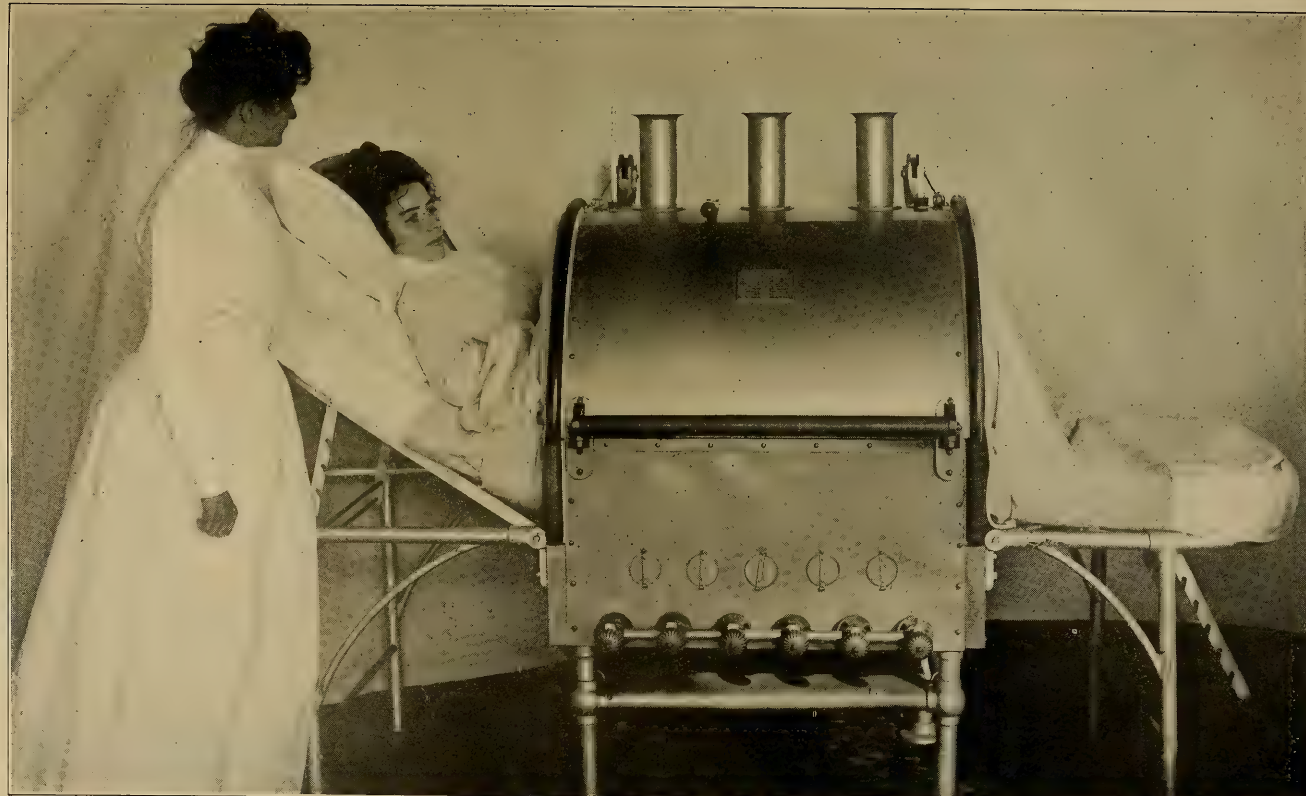

PLATE 243.—Showing patient receiving high degrees of heat to lower half of body.

PLATE 244.—Commencing the Alcohol Rub after treatment by Hot-Air Method.

PLATE 245.—Massage of Knee after Hot-Air Treatment.

PLATE 246.—Massage Process following Hot-Air Treatment in Body Apparatus.

put on the bath robe and slippers. When all is ready ask the patient to walk to the side of the machine, raise the top, place the wooden cover over the metallic side-arm to protect the patient from the hot contact and have him sit on it (or below it), and, with a side-swing of the body neatly achieve a full length dorsal decubitus on the couch which forms the bed of the apparatus. This non-conductor couch is at first cool and heats very slowly. Do not let a patient enter a machine in which the mattress has been allowed to remain hot. The body does not like a superheated *bed.* Always see that the mat is cool. Now remove the slippers and leave the feet bare.

Have the patient's head project out of the machine according to the needs of treatment. If you wish to treat the lower tissues mainly let the head come well out so as to clear the field of heat and keep cool easier. If you need to heat the upper thorax, or reach the shoulder, for instance, let the head be only just clear of the opening of the cylinder. With a little experience you can shift the patient up or down to secure the best results with the most comfort—and comfort during this treatment is a very important thing.

Now remove the wooden fender, close down the top of the cylinder, put the two thermometers in place, and prepare the patient. Tuck a folded small turkish towel under the chin and around the neck to cut off the hot air from the face. Adjust the canvas hood which finishes this end of the machine so that it is tucked closely under the chin and over the shoulders outside the towel, to act as a barrier to the escape of hot air beyond the parts it encloses. This takes but a few seconds.

Next go to the foot of the machine and place the canvas extension over the patient's feet, closing down also the canvas flap which completes this end of the apparatus so as to shut in the heat. Then open midway the ventilating draft of the funnels to secure *circulation* of the heated air, a most important feature of the treatment. These are the primary preparations and are to be quickly done so as to avoid loss of heat by keeping the machine open, and to get the patient started to warm up. *Details* of technic come next.

The patient now lies comfortably on his back with his hands at his side and the bath robe folded over him. Under him is a bed that feels cool in the warm cylinder. From above pours down a rain of fine streams of gradually increasing dry heat. It acts chiefly on the *uppermost* surface of the tissues, and if the patient raises the knee or lifts his hand nearer the roof of the cylinder he will feel the difference in temperature between the floor and the ceiling of his temporary prison. Instruct him not to touch the metallic parts or even the cork lining, though he can touch the cork with impunity, but let him occupy the middle of the couch and simply rest in the most comfortable position and throw open the robe to expose all the body. Do nothing further till the patient reports commencing perspiration.

Note the thermometers at head and foot of the machine. There will often be a marked difference in their reading. One may be fifteen or twenty degrees higher than the other, and this is caused by the direction in which the current of outer air passes through the room and affects the machine. But till perspiration begins and the head feels the heat the patient needs no special attention. It may be ten or more minutes before he says he is ready for the next step.

As soon as he reports a marked sense of heat with well-established perspiration, wet a small square of the turkish towelling in cold water, wring it partly out and lay it across the eyes and over the forehead. With the hands press it to good contact and let it remain till it feels too warm. Then wet and cool it again, and repeat this cool application to the forehead at short intervals till the séance ends. If the head feels more effects of the heat than this simple application relieves, lay a similar cold wet towel *under the nape of the neck.* It is wonderfully refreshing to some whose cerebral circulation is easily disturbed by the heat. It will be noted that the entire hair of the head is not wet. The cold damp cloth is only applied to the frontal region or to the back of the neck, and the vertex rarely needs the cold. This fact is very important in the treatment of women, whose hair would deter many from taking the treatment if it had to be wet, dried, and toileted at each séance. Men do not care, but most women object to a treatment which wets the head.

Now comes the question of *drink.* Do not fill each patient with routine ice-water "to promote perspiration." Generally omit water in corpulent persons and hydræmic states. Generally let thin patients drink freely. These have no fluid to spare from their tissues, while the hydræmic class should lose watery constituents from the system without resupplying them by drink during the treatment. Get this distinction clear in the mind as a guide to practice, but also accept the patient's wishes within reason. When perspiration has started or the patient asks for a drink have a lump of cracked ice in a glass, pour in fresh water and place in the tumbler either a glass tube or a patent "straw." When gratefully cool but not fully ice-cold, hold it so that the patient can suck it through the tube, as he cannot well otherwise drink in the recumbent position with his hands closed in the machine. A half glass of water twice during a séance is usually sufficient, but if a patient is thirsty and craves more let him have it.

For the most part regulate the quantity by the law of supply and demand. If you wish to maintain a balance in a thin or medium patient let him drink about as much as he perspires. If you wish to flush out the system with increased perspiration supply drink more in excess. If you wish to extract watery constituents and reduce obesity, œdema or exudates reduce the drink accordingly, relieving only special thirst. Avoid the internal shock of extremely cold ice-water. Have it only gratefully cool; or, in some cases, a hot drink will be more beneficial. Experience will teach this.

If a patient needs to wipe his nose or rub his eye, or pay any other attention to his face during treatment, simply pull up the canvas at one side of the neck so that he can get one hand to his face without letting in much cold air and close the canvas down again when he returns the hand to the cylinder. There is no inconvenience to the patient on this point during treatment. He can use his hands freely whenever he wishes to do so. Some want to keep their arms out of the body apparatus altogether and a patient can be humored in this respect if necessary, but it is preferable to have the arms in the cylinder so that the entire circulation below the head is acted on evenly by the heat. In cases which require treatment only below the waist line the upper portion of the body can be out of the apparatus, and the patient need be only partly recumbent. The above directions will then be modified accordingly. The various positions are beautifully shown in our Instruction Plates, which are without doubt the finest and most complete series of photographs ever made to illustrate this subject.

Having started the head to keep cool and comfortable the next thing in order is attention to the body in general and to the special part which requires either special treatment or safeguarding. Ask the patient if any part of the skin is getting too hot. If we want the entire system to be directly heated and with the least loss of time, ask the patient with his own hands inside the cylinder to lay off the anterior folds of the bath-robe so that the hot streams pour full upon the skin. Now any local irritable focus on the surface may be the seat of a burning sensation long before the general action is secured. The end of the penis, or the middle of the thighs, or the region of the patella, or the feet, may be the first to feel uncomfortably hot. Then have the patient draw the robe over such parts as he can protect with a layer of it, and on other parts as the need may arise lay a dry and small towel folded to cover the area affected. One or two layers of towel will usually be sufficient, but, if not, double the towel again.

By the time the séance is half through this adjustment of the conditions to the needs of the patient will be completed, and he will be prepared to enjoy the final rise of temperature to maximum where it will be maintained till the séance ends. It is only this latter half of the process that constitutes the active period of therapeutic treatment, but the gradual climb of the tissues with the thermometer is as indispensable as the maximum dosage.

When the front surface of the body has no particular indication which leads us to devote the entire time to it tell the patient to turn over and lie on his chest for the last ten minutes of the application. He does this without opening the machine, just as he would turn in bed, except that you must readjust the towel that was under the chin and fit the canvas sleeve closely around the back of the neck. Then continue the cooling of the head as before, and if any part needs protecting from irritable heat lay a towel over it as was done on the front surface. In opening the canvas at the foot of the machine to introduce these local protections close it again quickly to avoid loss of heat in the apparatus.

Make the first séance in the body machine only thirty minutes, and let the temperature rise only to the point of maximum *comfort*. The thermometer may read 230° or 240° F., more or less; perspiration may not be freely established, and at first the treatment is *preparatory* rather than therapeutic. Make the second séance forty minutes and note any increase in tolerance and facility of the sweat glands. At the third and future séances the tissues are accustomed to the method, the maximum dosage is ascertained, and the length of the treatment is adjusted to the effects. Bear in mind that the early part of each treatment is used in raising the dose to therapeutic activity, and that only about two-thirds of the time is actual treatment. Make forty or forty-five minutes the full average séance in this apparatus, and only exceed this limit in special cases.

Many will feel so cosily situated in the warmth and rest that they "want more," but unless indications require a full hour do not yield to mere desire of the patient. In the smaller applications to local parts longer séances are commonly cited, but do not induce too much relaxation by longer action upon the entire body. This is especially important when daily treatment is given, and tonic results will be turned into increasing debility if an excess of time is allowed.

Do not dose heat by a mechanical meter. Dose it by medical judgment aided by the thermometer and not by the thermometer alone. Do not begin by saying that you will give a certain new patient a certain number of heat degrees. The tolerance of patients for heat,

PLATE 247.—Hot-Air Treatment to Arm and Shoulder. Showing position for patient. Attendant is reading thermometer.

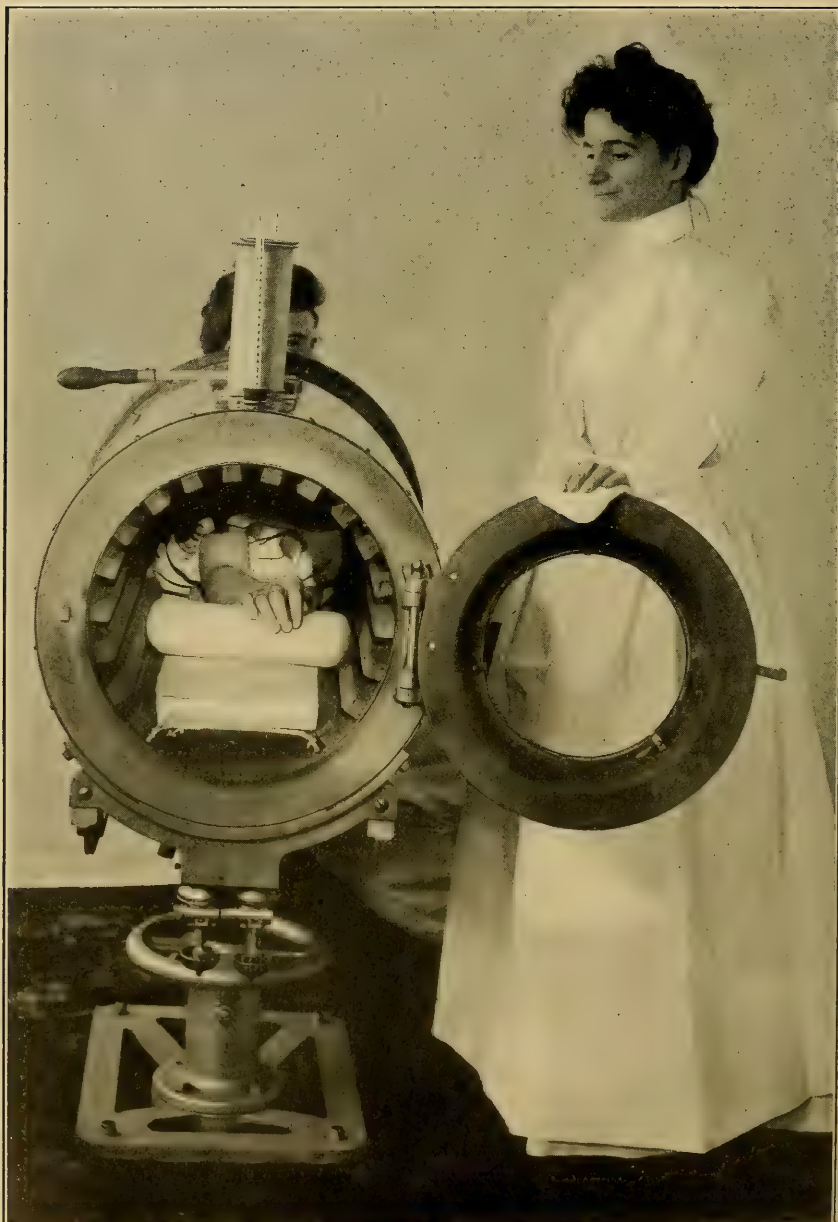

PLATE 248.—Showing Arm in Apparatus with hand resting on roll. End open showing entire interior ready to close for treatment.

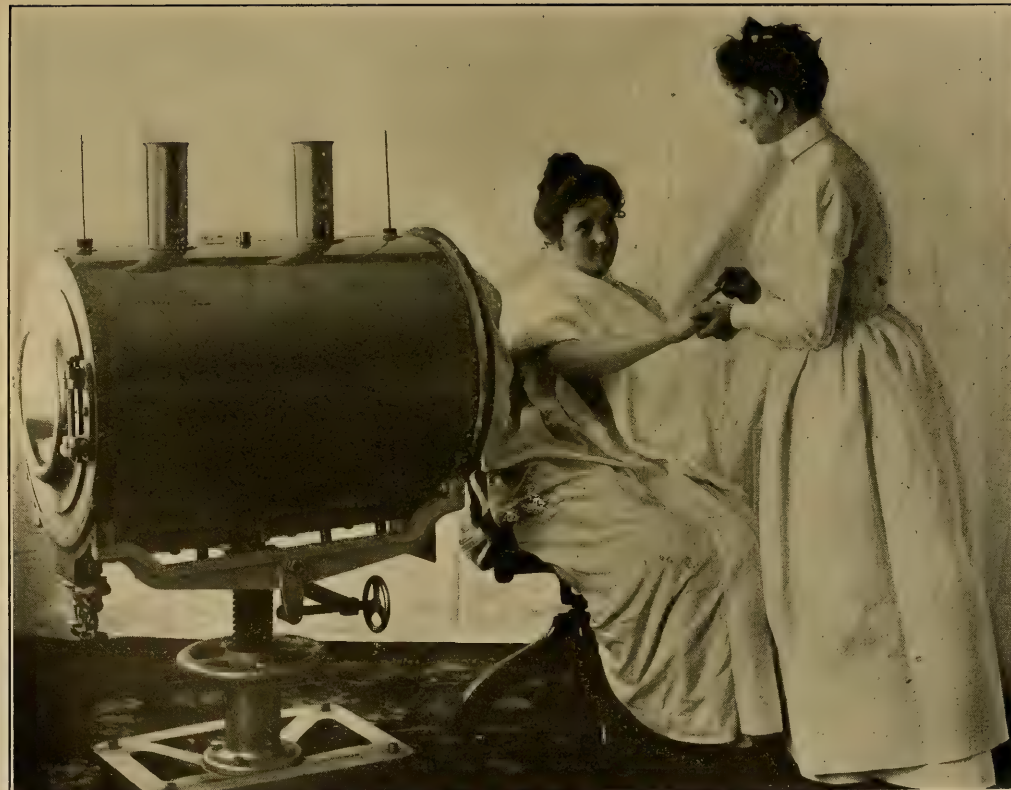

Plate 249.—Manipulating Arthritic Finger-joints after Hot-Air Treatment.

Plate 250.—Local Massage to Arm and Elbow after Hot-Air Treatment.

and benefit by heat, differs just about as cases differ in respect to dosage of drugs and electricity. As the mercury rises watch it and ask the patient if it still feels good. Coax it up to just the point where he ceases to say that the hotter it gets the better it feels, and then hold it there if it becomes comfortable, or slightly reduce it to comfortable general tolerance.

But if the thermometer shows that a therapeutic degree of heat is not yet reached when the patient reports *intolerance*, do not accept it as the proper dose as in the former case. Knowing about what the dose ought to be and failing to reach it with comfort, examine the part complained of and ascertain the cause of intolerance. If the skin is irritable in a local area cover it with a folded towel. If the cause is general and can hardly be attributed to the state of the skin look elsewhere. It may be that the head has not been kept well cooled. It may be due to a too-recent meal, or to some derangement of digestion, or the arterial condition. Seek and find the cause if possible, and if the treatment must be modified for the present séance do it with an understanding of the reason and take measures to have the next séance *secundum artem*. A favorable case which begins with 240° should thrive on 270° or 280° F., after four treatments, and if an active dosage cannot be reached within agreeable tolerance there must be a cause to seek and remove; 240° to 270° F. is a good average.

If the heat reaches maximum too long before the close of treatment turn down the gas to keep the heat even. If the thermometer drops a little later raise the gas as indicated. About five minutes before time to take out the patient turn out the gas. The next step is to open the cylinder and remove the patient to the massage-table.

When the full time has expired have the patient draw his robe over his body, if any part is uncovered, lift up the top of the machine, place the wooden fender on the side-arm over which the patient will climb out, and have him rise and step to the massage-table. If this is in an adjoining room put on his slippers before he walks. Also see to it that the room has been well ventilated and is not below seventy-four degrees. Too cool a room is undesirable, and any chill to the patient must be avoided.

Have him stand by the side of the massage-table, hold up in front of him a full-length sheet of turkish towelling, and ask him to throw off the damp wrapper and lie down on the table on his back. As he does this lay over him the large sheet of towelling, and, if he needs it, add a light single blanket. The covering will vary according to the season. In summer less is needed. If for any reason the patient has been unable to stay the full therapeutic time in the machine

—either because he is in a hurry, or the apparatus is wanted for another patient, or because his condition lacked tolerance—he can be taken out ten or more minutes too early, transferred to the massage-table, and allowed to complete his sweating there under extra blankets. The operator may wish to save his own time on occasions, and this little digression from regular technic is useful to know in practice.

The next thing is the sponging of the patient to remove sweat and debris. A hydro-therapeutic equipment and douches are important and well supplement hot air, but their consideration belongs to another treatise and we will only describe sponging here. This is done at once by the attendant. Have a pail (of about one-gallon size) half-filled with warm water. Also a very soft sponge as large as a baby's head. Add to the water in the pail about a dram of the soap solution and set up a little lather by squeezing out the sponge a few times. Then begin with one arm. Draw it out from under the sheet and sponge it off. Then dry it. Then dash a little alcohol on the palm and rub the arm as a cooling tonic measure. Repeat the same process on the other arm. Then lay the sheet off the lower part of one leg and sponge and dry it. Follow drying with the alcohol rub. Cover each part as fast as done and finish the two legs and the front of the body in sequence. If not ready to massage the patient at once have him sit up while the back is sponged and dried, but if ready to complete the massage treatment without delay have the patient turn over instead of sitting up, and sponge, dry, and finish the back with alcohol as taught.

Have the assistant begin massage at one foot and use gentleness at the beginning. Go over each leg twice. Let vigor of application develop gradually according to tolerance. Then massage the back for circulatory and lymphatic effects, turn patient on stomach and massage the anterior tissues as needed, and, lastly, do each arm. This is the rule in cases requiring no special *massage* therapeutics, and for whom this finishing treatment is only a tonic supplement to the cooling process. For others the masseur must meet the indications. If there is an inflamed joint begin the massage of that part above the inflammation. Good operators use cocoa-nut oil as a lubricant and again sponge off the skin after it. Plain liquid albolene would appear to be a superior and cleanly lubricant for this purpose. A motor-massage apparatus is admirable here.

The massage completes the full séance with the body apparatus. While a skilled masseur is a valuable assistant, yet manual massage takes considerable time, and by means of the new motor-vibration machines the application can be very quickly done, as taught in our section on these instruments. Any one using hot-air apparatus may well supplement it by mechanical massage. The patient is now free to dress and be dismissed, unless he prefer to recline or enjoy a nap in a room provided for this purpose. Institutions will have such rooms, but in private practice the patient will dress and go home as quickly as convenient.

In warm summer weather a patient can safely dress and go out within a short time after leaving the hot-air machine. It takes the circulation and temperature an hour or more to attain normal, but after a sponge and alcohol rub the patient can dress and go home in a half hour with entire safety, but should be quiet and rest till after the next light meal. But at other seasons of the year the character of the day will decide the precautions needed to avoid chilling the lungs or body. On raw days with penetrating cold, sharp winds the patient had better recline in a side room more than an hour after dressing if he has far to go. If he can get home soon with little exposure he may start earlier. Ordinary medical judgment will advise him on this point. A little excess of caution is wiser than much risk, and hot air should not be blamed for ill-effects due to wintry exposures too soon after a séance. The general susceptibility of patients differ, and this must also be taken into account in bad weather.

With a female attendant these directions apply equally to the treatment of women patients.

The Leg and Arm Machine.—In this apparatus the application is more local and limited, and certain features of the *general* treatment are omitted. Action is concentrated on local indications, and the séance is managed differently.

About ten minutes before the patient is ready light the gas-burner (first removing the mat from the cylinder to keep it cool till the patient enters) and have the patient remove the outer clothing from the entire body, and all clothing from the extremity or part to be treated. We will first teach the preparation of the lower extremity.

When the thermometer shows that the machine has heated up to 180° or 200° F. it is ready for the patient. Have him walk to the side of it and sit on the treatment chair. This should be a stout wooden, cane-seated, revolving chair that can be raised and lowered, and have a comfortable back and casters. Now fold a medium turkish towel (about a yard long) so that it is about six inches wide by its full length. Wind this around the upper third of the thigh if the knee is to be treated, or just above the knee if the ankle-joint is to be treated. That is, wrap it above the site of the lesion requiring the local action of heat. The object of this upper binder is twofold: it cuts off direct action on the tissues beyond the lower border and it serves as a base of attachment for the open towel next to be applied.

With the folded towel held in place by a thumb and finger, now spread over the leg from the binder to the foot another similar towel opened to a single layer and secure it to the binder with a safety-pin. Insert the pin so as to hold both towels together on the leg, but only pass the pin through the outer layers. A hot metallic pin against the skin may burn uncomfortably. Do not forget these little things. Next quickly adjust the level and height of the apparatus to the patient by a few turns of the set screws and insert the cool mat and the patient's leg. On each side of the leg place a roll of the same material as the mat to keep the leg and towels from contact with the hot and exposed sides of the cylinder which would scorch them. Tie down the canvas sleeve and make the patient as comfortable as possible. Now go to the other end of the machine to prepare the foot and areas which need protection rather than treatment. Remember that it is hottest nearest the roof, therefore instruct the patient to evert the foot and keep the toes flat on the cooler mat. Remember also that there is little perspiration from nails and knuckles, so that fingers and toes are less tolerant than thick soft parts which radiate heat by free evaporation from sweat-glands. Once in a while a patient reports a slight blister on some susceptible part after a séance in which he has been wholly unconscious of any burning sensation whatever, but as a rule all degrees of irritation can be spared the patient by simple attention to drying the moisture as it accumulates and by protecting tender exposed parts that must share the treatment.

If the knee-joint is the centre of treatment lay an extra folded towel over the foot and ankle. This will shield these sensitive parts from extreme heat where it is not needed. If the ankle requires treatment cover the toes and insert a layer of towel between each toe. In brief, expose to the greatest heat the area that needs it, and cover all other sensitive tissues with regard to the patient's comfort. For toes and many local applications some operators find layers of absorbent cotton preferable to the towelling. Experience will teach when to use it as an adjunct to the towels. About the foot it is especially adapted to protect the small joints.

The question of drink, so important in general treatment, hardly enters into a local séance. If the patient wants a drink during any particular séance give it to him. If not, omit it.

Having completed the above described measures it only remains to let the thermometer rise to establish free perspiration of the parts exposed. This usually causes no care till the heat registers from 280° to 300° F., when the attendant must begin to regularly dry the skin as the dosage rises. With a small square of the turkish towelling in the right hand pull a convenient corner of the canvas sleeve just enough open to insert the hand and softly wipe away the moisture on the exposed part. In doing this reach under the towel that lies on the leg without removing it. If the parts near the foot need drying go to the lower end of the machine, partly open the door, insert the hand and dry the skin and quickly close the door again to avoid unnecessary loss of heat. Repeat this drying process every four or five minutes, or as often as necessary for the comfort and care of the patient during the remainder of the treatment. The maximum dosage will depend on tolerance and the area under treatment, but for the extremities a range of from 300 to 450 degrees is about equivalent to a range of from 240 to 300 degrees in the general body machine. The majority of treatments use about 400° F., though in stating exact temperatures we must have regard to the method of inserting the thermometer in the apparatus. Some run it through a cork collar, while some allow the tube in direct contact with the hot metal. This will cause a higher reading for the same internal heat in the vicinity of the patient, so that all reports of temperature are not of even standard. Get your experience from your own apparatus and regulate the dose according to effects on the patient, as taught in another paragraph of this section.

No cold application to the head is required in these lesser local treatments. The duration of a séance may be limited by various reasons to less than an hour, but an hour is an excellent time to allow, as the after-treatment does not require the full technic which follows the use of the body apparatus. About five minutes before the time expires turn out the gas, or reduce it earlier if the machine has large bulk to keep it hot for some time.

The hot-air séance is now ended. Open the sleeve and lower door, remove the part and also take out the mat and rolls so that they may cool. Sponge the limb with the warm soapy solution as taught in directions for the body machine and dry it with the alcohol rub. Then follow the indications for more or less local massage and the patient may shortly dress and leave. This after-treatment may either be done on the massage-table for the repose and pleasure of the patient, or if the foot only is treated it may be done while he still sits in the chair. As the general system is but slightly exposed during a local séance a long cooling-off rest is not needed, and in summer no special delay is required. Wintry weather must be dealt with according to the condition of the patient, and on any but mild days a rest of a half-hour is advisable.

Upper Extremity.—We will now describe the care of an upper extremity. Light the machine and prepare the part and the heat exactly as for the exposure of a leg. Bring the folded towel under the axilla of the affected arm and over the opposite shoulder. To this pin the open towel close to the neck on the affected side and spread it in a single layer down the arm and over the hand. By means of the adjusting screws raise and tilt the cylinder to conform to the level and position of the extremity to be treated. Use the same canvas sleeves as for the leg, and when the thermometer reads 180° to 200° F. open the end door, insert the cool mat and two rolls, place the arm in the cylinder, push the patient's chair up close to the opening of the machine, tie the sleeve at the shoulder, and begin the séance.

The hand and elbow are sensitive areas. Cover with a double folded towel such parts of the extremity as do not require the direct application. Use the same judgment as taught in treating the leg. Lay a roll on each side of the forearm so that the patient will neither tend to push over to the lining of the cylinder beyond the mat nor cause the towels to scorch against the sides where the heat is greatest. But if a hand is being treated have the patient lightly grasp one of the rolls so that the surface of the hand is raised from the mat and opened somewhat to the heat. A protection of a layer of absorbent cotton is excellent for wasted and painful fingers, which in cases of arthritis are apt to feel intense heat acutely. Also pay sufficient attention to outer towels or any blanket laid over the opposite side of the patient to keep them from touching the hot metallic parts of the machine, as scorching them from carelessness is poor practice. It soon makes new blankets look old and dirty.

When perspiration is freely established and the heat rises to above 280° F., or a point of perceptible intensity to the patient, begin the drying care of the arm exactly as taught above in the case of the leg. Repeat it as needed during the séance, about every five minutes. Other details are the same as for the leg and need not be stated again.

Note that the Arm and Leg Machine has two canvas sleeves. The large one is for use in treatments of the shoulder, etc. When the shoulder or side of the body requires the heat in addition to, or exclusive of the rest of the arm, sit the patient so as to bring the area in the front opening of the cylinder, pin the usual towels in place above and over the part, and attach the "shoulder sleeve" instead of the smaller one. Then proceed as before.

When great heat reaches up near the face the canvas is not only very hot itself but radiates more heat upward than is comfortable for the patient. Therefore lay a double fold of towelling closely against the neck and over the top of the canvas. This will keep an excess of hot air from the head and face.

In any exposure, either of an upper or lower extremity, do not let the patient who has removed much of his clothing complain that while he is "roasting on one side he is freezing on the other;" nor allow a patient to sit on the exposed seat of the chair with only undergarments on. Always throw a folded blanket on the seat of the chair and up the back of it in all seasons when it is needed, and cover the side of the body not treated with a suitable wrap or blanket. Keep the patient comfortable on all sides during the séance. Do not forget to take out the thermometers and shut the ventilating-funnel drafts while heating up the machine for the reception of the patient. Otherwise it will take longer to heat. Have the holes in the top closed by the canvas sleeves till the heat rises and the cylinder is opened to admit the part. Freshly air the treatment-room before and after each patient, as the atmosphere needs attention in this respect, both on account of the actual heat and to dispose of the products of combustion. Open the funnels as soon as the séance begins, for a circulation through the apparatus is required for treatment.

The leg and arm machine can be used for any single extremity, in whole or in part; for one shoulder; for a side of the body; for the hip-joint and lumbar region. When two hands require treatment, or two feet, they may both be well exposed in this cylinder, but when the main portions of two extremities need treatment at the same time there is generally a systemic as well as mechanical reason for using the body cylinder. Do not limit the séance to a local part, even if it will fit in the small cylinder alone, if the general state calls for constitutional effects. Much judgment may be exercised in the selection of the cylinder and the management of the treatment on a local or general basis.

In regard to sensitiveness of the skin it may be remarked that erythema and irritable states are sensitive to X-ray action, to labile electric-current applications, to friction with coarse towels, and to heat. A pale skin without foci of eruption is not likely to be sensitive, and tolerance can be expertly estimated almost at a glance. Conditions likely to be aggravated by heat are visible to the eye in a great many cases and annoyance to patients is therefore avoidable.

Study of Mistakes and Failures.—Thermæro-therapy has so large a destiny before it that it is important to consider some of the mistakes made by beginners in the uses of hot air in order that clinical investigation may not confuse the subject of results. The mistakes of the inexperienced lead to failures. These failures arise mostly from one or more of the following causes which we shall now discuss:

1. The use of poorly constructed and dangerous apparatus.
2. The application of this treatment to unsuitable cases.
3. Errors in the duration and frequency of treatment.
4. Failure to conserve the comfort and welfare of the patient during and *after* a séance.
5. Errors in the management of complications.

Every one knows that tools, bicycles, pianos, houses, shoes, and even drugs are made in different grades of quality. This is true of every form of therapeutic apparatus, and hot-air machines are no exception to the rule. If demand for low price clamors loud enough it will always create a supply of inferior work and material, and we may be allowed to point out that sometimes cheapness is dangerous. Since the popularizing of hot-air therapy various forms of apparatus have been devised—some constructed on the most primitive principles; others more elaborate, with all that ingenuity can suggest to secure the comfort and safety of the patient. A gas radiator to heat a hall bedroom may be light and movable as a lamp, but if a light and easily moved hot-air device was suddenly overturned by an unwitting movement of a patient, imagine the consequences. If it capsized with the gas out it would be bad enough, but if flames spread to the clothing, the patient, and the room, there would be a costly sequel to economy. But this is not the only consideration, and the essential requisites of a good apparatus are:

1. Massive construction to secure safety, stability, and endurance, and to hold the heat.
2. Mechanical arrangements which permit the temperature to be raised gradually and evenly to above 400° F., be sustained with ease at any dosage required, and be always under perfect control.
3. An automatic ventilating system to keep the hot air dry, *circulating*, and fresh.

"The products of combustion and the materies morbii thrown off from the patient's body should not be retained in the apparatus in contact with the patient but should be carried out through apertures for this purpose. A certain adjustability of position is also

PLATE 251.—Showing method of protecting toes in leg apparatus. End open, leg on mattress, attendant opening ventilating funnels, and patient ready to have door shut and commence treatment. During séance have patient turn foot to either side so as to remove toes farthest from roof of machine.

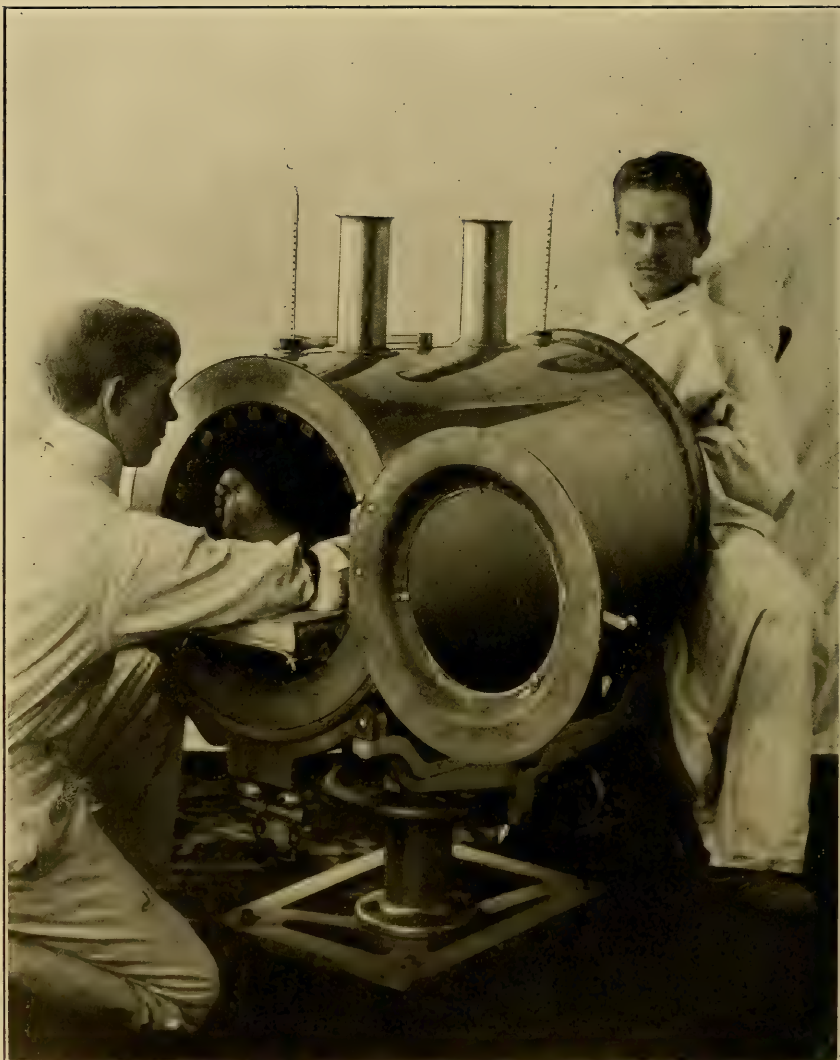

PLATE 252.—Showing patient midway in leg treatment begun in last plate. Attendant has opened the end door and is wiping perspiration from lower part of limb. To avoid escape of heat do it quickly and close the door as soon as possible.

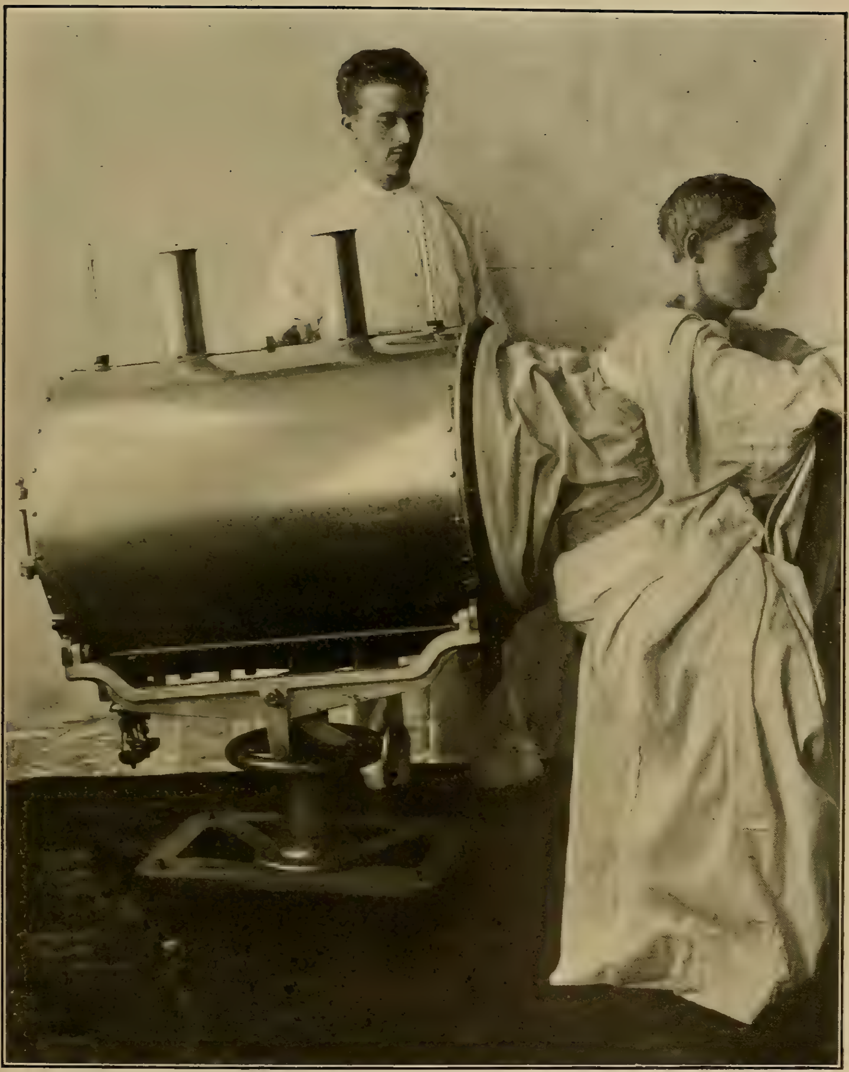

PLATE 253.—Local Spinal Application of Hot-Air by Sprague Method. Showing patient reversed on chair with canvas hood directing high-degrees of dry heat to lumbar region. Attendant is noting thermometer.

Plate 254.—Hot-Air Application to Hip-joint. Patient resting on Massage table, and apparatus drawn up with canvas hood covering hip.

required, and free movement of the part (or entire patient) must be compatible with absolute protection from metallic contact or liability of any kind of burning or overturning. Speaking generally, the apparatus should be so constructed that with ordinary care a patient need never experience the slightest discomfort, and danger of accident be completely eliminated. Any machine, large or small, local or general, that does not meet these indispensable requirements will be a constant source of uneasiness and dissatisfaction to the practitioner himself, and will not confer on the patient the whole benefit he ought to receive.

The novice can hardly avoid applying this treatment to some unsuitable cases: nor can the expert at all times predict the result of treatment in advance, but practice and study reduce the percentage of failures from this cause. Study the limitations of scientific thermæro-therapy as well as its main usefulness and eke out its action by judicious supporting measures. Hot air may furnish but one crutch to a cripple when he needs two; supply the other with whatever means your skill and the materia medica enable you to prescribe.

Cases abandoned as incurable under other therapeutic measures have sometimes been greatly benefited by hot air, but do not expect radical and permanent improvement in every case otherwise hopeless, even though this conservatism conflicts with circulars you may have read. It is difficult to state in text the precise conditions which make a technic or a dosage applicable, for occasionally the most desperate cases respond marvellously, while others with apparently plain indications and prospects prove refractory. Clinical discrimination grows with experience, however, and in time most cases can be classified at sight or after one test treatment. As a general rule a very hopeful prognosis may be made in all acute and subacute conditions within the scope of thermæro-therapy. In chronic cases of the same kind results should still be good, but much depends on the length of time the particular disease has lasted. In arthritic disease the extent and permanence of the bony and cartilaginous changes that have taken place in the affected structures must be regarded by the beginner ere he makes too favorable a prognosis. The mistake of being more hopeful than the facts and sound practice justify is not an inherent fault of hot air.

But what are "unsuitable" cases in general? In the main they are those in which either or all of the three chief actions of hot air are contra-indicated. With this clinical guide any rational medical judgment can steer clear of very gross errors in advising patients to take the treatment. Cardiac affections do not necessarily make a patient "unsuitable," as we have seen elsewhere, for vast numbers of rheumatic patients are also the subject of some form of heart disease. Happily the evidence that hot air is compatible with relief of rheumatism without injury, nay, even with benefit to the arteries and heart, is well-nigh conclusive. The immediate effect of the treatment is to dilate the arterioles and increase the vigor and ease of the heart's action by relieving part of its labor. It can therefore be readily seen that in all forms of cardiac involvement where stimulation is required (especially if compensation is failing or has completely broken down) the effect must be beneficial and that with reasonable care during the séance these cases are not to be rejected.

Let us now consider possible errors in the duration and frequency of treatment. The general principles governing frequency of treatment are nearly the same with all forms of therapeutic apparatus with which the author is acquainted. These are well understood, and under the instruction of experience are interpreted at sight. Acute diseases call for a short sharp attack; long lasting conditions need a deliberate siege. Haste will serve one purpose and defeat the other. The novice must master this basic principle of therapeutics once for all, and then, whether we teach hot-air, or mechano-, or hydro-, or electro-therapy, or any other means of influencing physiological actions the same rule applies to each, with proper allowance for different dosage and energy of action.

Daily séances for ordinary acute conditions and three times a week for chronic cases is the average rule, subject to such exceptions as circumstances soon lead us to make in our individual practice. But in thermæro-therapy there is yet a word to be said beyond this: when the patient's disease is both severe and chronic and vitality has been lowered by pain and sleepless nights the treatment must not be pushed too vigorously. Two treatments a week may be all that the patient will bear till the worst features of the case have been improved. And here it must be borne in mind that in certain cases the first treatment often not only does not give relief, but appears to aggravate the symptoms, particularly the pain. With the fourth or fifth treatment, however, improvement usually sets in and steadily continues, and then séances can be increased to three per week. In ordinary cases the sense of relief begins at once, and when this occurs the caution above referred to is unnecessary.

Further, the sudden cessation of hot-air treatment in chronic diseases is generally unwise, and may be actually injurious. It is a far better plan to gradually increase the intervals between séances after a maximum of improvement is secured rather than stop abruptly. This is particularly important when the kidneys are diseased. We aim to secure benefit to the system by the vicarious action of the skin promoted to a high degree by dry hot air. To suddenly cease the free perspiration might tax the weakened kidneys more than they could perform. Shade off treatments to once a week, and then once in ten days before stopping a very chronic case who has had a long course of hot air.

Avoid the error of making first exposures too long or too high temperature. As a rule in chronic cases allow three séances for the education of the tissues to a state of full tolerance. Then you know your patient and have not lost any of his confidence by ten degrees too much the first day. Do not make any exposures too long or too frequent. Perhaps no mistake on the part of the novice reacts on him quicker than failure to secure the comfort and welfare of the patient during and after the treatment. A test treatment in the body apparatus on the physician's own person will explain why this is so. Many patients are very nervous when beginning a new and untried treatment which all know must be skilfully given. It is natural for them to suppose that the application of heat far above the boiling point of water must certainly pain or burn. Allay their fears by proper explantions and by a first séance kept well within the bounds of absolute comfort to the tissues. Let the dose rise very gradually as confidence gains the place of timidity. Or, first treat only one limb and advance as you can with care. Never handle the stranger to hot air as a veteran who wants it hot and wants it long. Work gently till benefits have banished neurotic fears and all goes well.

Be certain to avoid the mistake of giving any treatment, especially with the leg and arm machine, with the patient in less than the most comfortable attitude and position. It is often very irksome, for instance, for a patient with sciatica to sit with one leg extended in the machine and remain immovably in that attitude for an hour. Starting with the most comfortable position attainable let him shift the leg a little from time to time and assist the process so that the least disturbance will occur. Or, let the treatment be taken in the recumbent machine till he improves. In the body machine do not insist on keeping a man on his back the entire hour. Let him turn and twist as he needs for comfort. He can turn over twice if he feels taxed by lack of change in posture.

Do not make the mistake of attaching too little importance to cooling the patient's head during a body treatment. Follow the teachings of this section in this respect. As to drink, do not let any patient pour into his stomach a large glass of ice-water. Nausea and shock may follow. Small quantities more frequently repeated are better. But one of the chief errors to avoid is a body treatment nearly on top of any meal, or less than two hours after a hearty meal. Local treatments may be given an hour after a meal. So may a body treatment an hour to an hour and a half after a very light meal, but if the patient has eaten heartily two hours should pass before digestion encounters a treatment which so alters the circulation and raises the temperature. Perhaps neglect of this precaution causes more distress than patients suspect, and a delay of the hearty meal till after treatment is taken will be good advice to many. But also avoid a hearty meal *soon* after a hot-air séance. Time to allow the circulation to settle is needed. Let the first meal after a treatment be light. Old frequenters of Turkish baths need not be told this, but the novice who is treated for the first time should have a caution. Burns rarely occur with the body apparatus and may easily be avoided in the local apparatus by proper care as herein taught.

But granted that the operator has made no mistake in a given case and yet the patient shows signs of distress, what then? If the patient complains of a sense of excessive heat and the heat is actually high moderate it at once; if the heat is not high and the patient feels unwell and none of the usual measures relieve the distress remove him at once from the apparatus to the massage-table. There cover him and let him revive at rest. This may happen with an old and accustomed patient who takes a treatment with some temporarily deranged state of the system which passed unnoticed till aggravated by high heat. The next time all may go well. The point is that when all is not well with the patient, and you do not find the fault so as to correct it, it is better to cut short the single séance than to persist for a half hour of dissatisfaction which the patient will not speedily forget.

Subsequent colds may usually be avoided by not permitting the patient to leave the premises, especially in cold and stormy weather, till the body has been thoroughly cooled that even if delay is irksome to a business man do not make the mistake of unwise haste on this point. A congestive chill is easily developed when a sharp north winter-wind strikes a patient who has been an hour in contact with 280 or more degrees of temperature with every artery and capillary dilated and the skin like a sieve.

The study of these sides of the picture, which usually dazzles us with nothing but clinical results brilliant beyond the wildest dreams

PLATE 255.—Method of wrapping patient's arm in heavy Turkish towelling preparatory to arm treatment in a Betz apparatus.

The series of fourteen Instruction Plates next presented demonstrate the Betz methods of treatment, and were photographed exclusively for this work.

PLATE 256.—Wrapping of arm completed, and patient ready to insert it in cylinder, as shown in next plate.

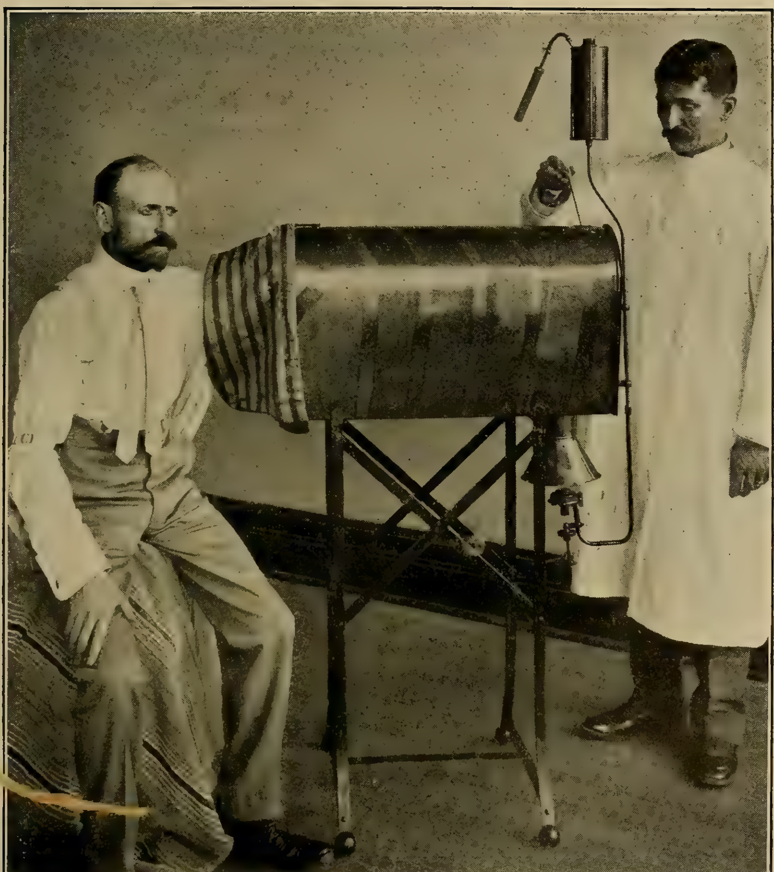

PLATE 257.—Showing arm in apparatus, and attendant reading thermometer.

PLATE 258.—Showing method of preparing leg for Hot-Air treatment to knee in Betz apparatus, as shown in next Instruction Plate.

of Sydenham or Hahnemann, will profit much during the first six months of hot-air therapy. Simple precautions will minister greatly to the security and well-being of the patient and add to the success of treatment. They will prevent the accidents and unpleasant complications which have too often in the past discouraged the employment of this extremely valuable method of combating certain difficult diseases. And in closing this consideration of avoidable mistakes which interfere with the best results, let us briefly again urge every physician who uses either hot air or any other therapeutic apparatus to *avoid relying on its exclusive and unsupported action to meet the entire indications of every case.*

Study adjunct prescribing. Especially take note of personal hygiene and advise the patient in ways that will supplement the practical therapeutics. This is particularly needful in the use of hot air, which is often a last resort for cases otherwise resistant to prescribing; and one of the great functions of thermæro-therapy is not alone a direct curative action on an incurable disease, but rather a preparation of the tissues to benefit in an increased way by accelerated physiological processes and by adjunct therapeutics which were planted on barren soil till the tissues were warmed and wakened by full tides of hot blood set free by hot air.

Clinical Experience.—To know what others are doing with hot air is to know what we may also do with it ourselves. No one can tell whether a therapeutic claim is well-founded or not till he tests it himself with such skill in technic that failure will not be the fault of inexperience. From lists of diseases successfully treated extract the *principles of action that must have established the results*, and then study to apply these principles according to the indications of your own patients. In this way mere imitation of others will give place to genuinely scientific therapeutics, with a great increase in benefit to all concerned. The following reports are therefore not cited to index a list of cases that may be treated with hot air, but to suggest lines of clinical study and instruction. In reading them aim to associate the physiological action with the diagnosis so that your own future prescribing of this form of therapy may be accurate and successful.

"A thorough and careful investigation of 200 cases (to which over 2,000 treatments have been given within the last twelve months), many of whom were under my immediate and personal care, has afforded good opportunity to note the wide repertoire of diseases amenable to this treatment, and the list is not yet complete, as from day to day new developments are brought forth by the continued use of this manner of administering the dry hot-air as a therapeutic agent.

"The discovery of the very great benefit to be obtained in various complications and neurotic conditions was accidental, in so far as such a patient was at first present not for treatment of that existing chronic condition, but in consequence of localized pain, as Lumbago, Sciatica, muscular Rheumatism, etc., or of a bicycle accident or trauma of some sort. Such patients, being relieved of the original local or traumatic cause of the trouble which induced them to take the hot-air treatments, also found the general systemic effect so beneficial that not a few, on this account, continued treatments, and have thereby in many instances been entirely cured, and in others so satisfactorily relieved of uncomfortable and disagreeable symptoms that they have considered it necessary to continue. Under this observation come many cases of Anæmia, Chlorosis, Neurosis, and Insomnia, one each of Tobacco heart, Atheroma of the arteries, Pleurisy, Asthma, and Biliary Colic. Cases of Kidney, Liver, and cutaneous affections, and almost all diseases consequent to a gouty or rheumatic diathesis, have yielded surprisingly favorable results.

"We are convinced that its uses are far-reaching and radically and beneficially effective. Our experience leads us to believe that a diseased ovary, for which formerly there seemed no alternative but the surgeon's knife, may now, through this method, be retained by its possessor in comparative health; the subsequent condition of the patient comparing most favorably with others similarly affected who have sacrificed the organ. Cases of persistent Dysmenorrhea, Catarrhal condition of the Uterus, Endometritis, Cervicitis, etc., yield more favorably and permanently to this treatment of hot air than to the hot douche, medicated tampons, or the curette; while in Uræmia and the Albuminuria of Pregnancy it is a most valuable aid. The body hot-air machine is generally better adapted to all *systemic diseases and those of the trunk.* The arm and leg machine concentrates its power most favorably on local manifestations of both disease and trauma of the extremities, *e.g.*, Sciatica, sprains, bruises, bicycle accidents, etc. Lumbago, Myalgia, Tonsillitis, and Coryza have each been relieved in one treatment, but certain forms of Rheumatism and Gout require many and oft-repeated treatments. This is often noticeably the case in Rheumatoid Arthritis; the pain can be overcome often quickly and effectively, but the perfect mobility of the joints and the lessening, if not the entire eradication of the deformity, would require a long course of treatments. So far, the patients have been relieved of the soreness, pain, and *distressing* symptoms, and have felt so satisfied and comfortable with the improved conditions that a long continuance of the treatments was not persevered in, hence the possibilities of completely reducing the deformities have not been thoroughly tested, although in many cases there have been a marked decrease of the enlarged joints and entire disappearance of the gouty tophi. The concretions in and about the joint are broken up and these once solidified deposits become softened through the excretory organs. The blood becomes heated from one to five degrees and the circulation correspondingly accelerated, and to these facts are due largely the good effects, as the various avenues of the human system are stimulated to acting, and metabolism is promoted." (DIGHT.)

The treatment of all forms of arthritis from the simple traumatic case to advanced rheumatoid arthritis illustrates in a peculiarly interesting manner the reinforcement of hot air by static electricity. Take the tissues, warm and soft from the hot-air séance, with capillaries dilated and with intensified local vascularity, and immediately subject them to the alterative-nutritional-sedative-tonic action of special static treatment and the benefit to the patient will be very greatly enhanced. As the patient must wait any way to cool off it will waste no time.

Wring lightly out a towel wet in a soda solution of water as hot as is comfortable, wrap it around the joint and outside of this wind the regular chain used for connecting the patient with the machine. Have the patient sit in any suitable chair (or recline on a couch) placed on the insulating platform as for ordinary treatment. Hook this chain on the positive sliding pole and ground the negative pole. Push the poles together and start the machine into action. Gradually draw the poles apart till deep, firm, constriction or moderate muscular contraction is produced and maintain this dosage with rapid interruptions of the current for about ten minutes. Then reduce the speed of the plates, make very slow interruptions, and by pulling still further apart the pole pieces make a few stimulating slow contractions of the muscles to end the séance in cases in which stimulation is needed. When sedation is needed end the séance with the rapid interruptions and reduce them gently to zero. Then dry the part, dust it with toilet powder, and prepare the patient to go home. Massage is not needed with this treatment. In cases of the smaller joints use a water-bath contact for the current. These technics are all taught in the author's little book on "Elements of Correct Technique," and the water-bath treatment with a rapidly interrupted high potential current is peculiarly gratifying in cases of rheumatoid arthritis affecting one or both hands, and one or both feet. The combination of hot air and electricity is undoubtedly better than any one therapy alone.

"When the effusion is extensive, surgical means (incision or paracentesis) must be employed for its evacuation, but frequent topical applications of heat (400° F.) will prevent the reaccumulation of serous fluid. The following case well illustrates this: Mr. S., aged twenty-two, a book-keeper, received, while at play, a blow with a base-ball, which 'laid him up.' The knee swelled and the attending physician tapped the joint-cavity, evacuating a glassful of fluid. The man returned to work. The fluid reaccumulated, necessitating another tapping. This procedure had to be repeated every two weeks. After the fourth tapping the patient sought my advice with a view of having arthrotomy performed. I removed about ten ounces of fluid and ordered the nurse to at once treat his knee for an hour with dry, hot air, raising the temperature as high as the patient could bear. He received five more such applications daily, and the knee has been in good condition ever since (five months)." (BLECH.)

In the treatment of joint diseases do not make the mistake of restricting treatment to *local* hot air when a *constitutional* factor is present. In syphilitic and gouty arthritis and in all other cases failure to meet the constitutional indications will disappoint you with any local remedy. Use hot air as an adjunct of great value, but do not neglect to make your therapeutics *complete.*

"Hot air is a pain-relieving agent of unequalled value in those conditions where its application is indicated and possible, because of its very constant effectiveness, rapidity of action, and the absolute absence of deleterious after-effects. In rheumatism, at least, its action is so profound in connection with judiciously chosen drugs that it may almost claim a positive curative power of its own, and may certainly be said to be the most powerful contributing agent we now know of. Many cases cannot be cured by drugs without it, and in any case the victory over the ailment is much hastened and the victim maintained in comfort during the attack. On the other hand, we must remember that it appears to be rarely if ever capable of overcoming the disease without the aid of drugs.

"It is capable of stimulating tissue repair to a remarkable degree, as is demonstrated by its effect upon sprains, and, as I shall show in a future article, on at least many cases of intractable varicose ulcers. It is capable of influencing most happily septic inflammations of serous membranes, as shown by its action in peritonitis and pleurisy. It will many times at least give us the power of economizing nervous energy by relieving pain and other more or less dangerous conditions in pneumonia, thereby enabling us to refrain from sedatives and cardiac stimulation, and the nervous energy we may thus save for the patient will sometimes be sufficient to tide him over a crisis by which he would otherwise be overwhelmed.

"We cannot expect hot air or any other one measure to do everything. What I assert is that it will do a great deal, and that its powers are exerted in a direction in which we have hitherto been lamentably deficient; hence its addition to our armamentarium will enable us to increase by a large percentage the sum total of our

PLATE 259.—Application of Dry Hot-Air to Knee. Attendant reading thermometer.

PLATE 260.—Showing entire leg under treatment in the Betz leg and arm apparatus.

PLATE 261.—Wrapping the body in Turkish towelling for treatment of either lumbar region or abdomen.

PLATE 262.—Showing application of dry heat to chest for bronchitis, pleurisy, pneumonia, etc.

power over disease. The capabilities which it has so far manifested, and we have as yet only begun to investigate them, are sufficiently weighty to justify belief that dry heat of high degree is destined to become a therapeutic agent of as great popularity as it possesses diversified applicability." (SKINNER.)

Dr. Skinner also discusses the aid of hot air in pneumonia, in which it is indicated and effective only as regards local lesions. He says:

"The indications for hot air are:

"1. To relieve pleuritic pains as a substitute for opiates, to which it is superior.

"2. To relieve the harassing cough instead of sedatives, to which it is superior.

"3. To relieve the heart from the strain of massive exudate instead of alcohol, digitalis, strychnine, etc., to which it is superior, primarily and secondarily.

"I have never seen any shortening in the duration of the disease. The characteristic respiration, the pulse rate, variations in temperature, prostration, sweats, etc., run their course. They may be somewhat mitigated in intensity, but whatever general benefit accrues is due to the relief of reflex disturbances and cardiac distension. The exudate has disappeared so that so far as physical signs would show, the pulmonary tissues were clear in from three to five days. In pneumonia hot air has not failed to give me the desired result much better than any other measures."

He has, however, found that convalescence after the use of hot air was, in some cases, very slow and protracted. Perhaps in such severe cases the patient would not have lived at all without the relief afforded the heart by hot air, but none who encounter slow recoveries or debility during convalescence need let their patients drag tediously along. Put them on the static platform; give them a few mild tonic sparks to the general muscles and counter-irritation to the spine, and one week of such treatment will speed them to recovery faster than months of routine advice. If the operator has the skill to do it a few properly dosed sparks on the chest and over the apex of the heart will strengthen respiration and pulse in a wonderful manner. Over and over again I have given regularity and volume to a weak intermittent heart and restored comfort to the patient by sparks on the apex and cervical centre—the application not taking ten seconds of time. The relief was as quick as the sparks. Therefore, use this adjunct with your hot air and avoid delay in convalescence when it is possible. It may be assumed that during the last five years every physician at all interested in scientific medical electricity has procured one or more of the author's three major volumes on electro-therapeutics and is familiar with approved methods of administration. The author hopes to re-write his Static Manual and illustrate it in a manner similar to this course of instruction at no distant date. The necessity of attending to private practice is somewhat of a hindrance to much writing, however, and at present no plans can be begun.

Referring to the use of superheated air in chronic catarrh of the middle ear Dr. Hopkins of Cleveland writes as follows:

"Few ear diseases are so obstinate. Four years ago while using hot air extensively for various joint diseases it occurred to me that the same method specially localized might do good in such cases of otitis media as have ankylosis of the ossicles. Tests proved that when the obstacles to the local application were overcome the results were most brilliant. The method has since been employed in a large number of cases of this type with highly satisfactory results, and with improved technic the treatment has become simple, safe, and satisfactory. Of sixty-two cases treated during the last four years but four have been failures, all of them old people with extensive labyrinthine involvement. It would appear that any physician who will study the technique closely can secure equally good results.

"The intense heat seems to stimulate the circulation on the posterior side of the manubrium, causing absorption of the articular deposits, removing atrophy and relieving the rigidity of the tensor tympani. The ossicles lie so near the surface that they receive the full benefit of heat applied to the tympanum, and adhesions between portions of the ossicular chain and the adjoining bony walls of the middle ear are readily removed. Naturally much better results are secured in the same period of time in hypertrophic cases than in those of hyperplasia, but many cases of the latter type, which would ordinarily have been regarded as hopeless, have gradually improved under this treatment until marked benefit was secured. Arterio-sclerosis, serous effusions into the tympanum, and perforations of the tympanum have been regarded as contra-indications for this treatment, but more recently we have treated several cases in which small perforations existed without meeting any difficulty. Care should be exercised in these.

"Aside from headache there have been no troublesome after effects to require attention. Such accessory forms of treatment as may be indicated should not be neglected. An account of the first case treated will be especially instructive, as it has stood the test of four years time with no evidence of recurrence. J. L., aged fifty-three; good history and general health; has had nasal catarrh for fifteen years and gradually increasing deafness for ten years. Had a typical case of hypertrophic rhinitis. With left ear could faintly hear watch tick in very close contact. With right ear could hear tick at three inches.

"Diagnosis: Chronic catarrhal otitis media, with sclerosis and displacement of the tympanum, ankylosis of the ossicles, slight dilatation of the Eustachian tube, and some labyrinthine involvement. This diagnosis was confirmed by two colleagues of reputation as aurists before test treatment with hot air was begun. Before this treatment was tried he had derived no benefit from two years of regular systematic treatment on usual lines.

"Technic. The ear was thoroughly cleaned with alcohol for several days prior to the first séance. On presentation for hot-air treatment the ear was examined and found clean, the patient seated in a comfortable chair, the ear packed with narrow strips of dry gauze, and a large pad of dry gauze placed over the ear. The ear was then covered with the canvas sleeve of the apparatus and a current of hot air directed into the canal. The temperature was raised gradually till it attained 400° F. This was easily borne when evenly and slowly developed, the only discomfort being a severe headache after treatment, which was always relieved by a dose of codeine. See Instruction Plate No. 269 illustrating the method.

"Next, the Eustachian tube was inflated with a warm stimulating vapor from a nebulizer, and vibratory massage with the nebulizer completed the séance.

"The patient was kept in the office half an hour after treatment to cool the tissues before being allowed to go home and the ear was tightly packed with warm cotton before he went. The nose and pharynx received appropriate treatment with antiseptic washes, etc. Treatments were given on alternate days for three months. He could then hear the watch tick distinctly at thirty-four inches and responded to a whisper. All this treatment had been given the left ear. The right ear was then similarly treated, and in ten weeks an equally good result was secured. On examination the ears were normal in appearance. Careful tests at frequent intervals during the last four years have shown no tendency to recurrence."

From among a large number of studies of hot-air experience we select that of a physician to the N. W. London hospital as being concise, impartial, and instructive:

"In this communication I purpose to epitomize the results of several years' work on the treatment of numerous diseases by the local application of dry hot air. Since the publication of my articles on the subject a few years ago I have continued the investigations both in hospital and private practice, and as time has gone on I have become more and more convinced of the great advance in therapeutics which this form of treatment has brought about. The youngest patient treated was a child just three years old, a boy, suffering from epilepsy, and the oldest a woman of ninety-three, afflicted with chronic rheumatism, especially in the hands, accompanied by a considerable amount of pain. Both these patients were treated as out-patients, and did well. More diseased conditions than might at first sight be imagined are benefited by local hot-air treatment. My rule at the hospital for some years has been, when a patient suffering from any complaint does not improve after a few weeks' routine drug treatment, to order the hot-air treatment, and I must say that in the majority of cases improvement very quickly shows itself, often to a marked degree.

"The cases for which this treatment is especially indicated are all forms of *arthritis*, whether of rheumatic, gouty, neurotic, tuberculous, or traumatic origin, particularly when the process is chronic. I can say with confidence that almost every kind of joint mischief, whether the result of injury or disease, is greatly benefited by local hot-air treatment. Under joint diseases the following would be included, gout (acute, subacute, and chronic), rheumatism (acute, subacute, and chronic), gonorrheal rheumatism, rheumatoid arthritis, scrofulous disease of joints (for example, morbus coxæ), synovitis, bursitis, periostitis, including syphilitic and all forms of adhesions. With regard to *injuries* (recent and old-standing), synovitis, bursitis, and all degrees of stiffness, adhesions, and various conditions of immobility a few words are desirable. Many of these cases are greatly improved simply by the local application of heat, but, of course, if severe or old standing surgical interference by breaking down adhesions greatly increases and accelerates the cure. It is in most cases better to give a course of local treatment before any attempt is made to break down adhesions. Then an anæsthetic may be administered and the adhesions broken down and joints freely moved and placed *immediately afterward* in a hot-air apparatus. This frequently prevents the subsequent effusion and greatly diminishes the pain; in fact, I have notes of several cases of severe old-standing adhesions treated in this way with little or no pain or even effusion following the operation and with very satisfactory results.

"*Hysterical joints* I have found to be amenable to this treatment: One case occurred in a woman, aged twenty-three, who when admitted into the hospital had been unable to walk for two years owing to contraction of the left knee-joint; she had had some stiffness of this joint for five years. After two months' treatment she left the hospital able to walk. So again, cases of either local or general *malnutrition*, especially cases of feeble circulation, due to local causes such as injuries to blood-vessels or nerves, chilblains, cold extremities, and deformities due to arrested nutrition usually improve, as do most forms of localized œdema. Most forms of *neuritis*, both gouty and those of a more directly nervous nature (such as peripheral neuritis and traumatic neuritis) do remarkably well; and also sciatica, lumbago, and allied affections, including neuralgia following herpes zoster, are usually cured. I have had most satisfactory results in a large number of cases of *chorea*. The movements of the limb under treatment rapidly subside while under the influence of the heat, usually returning with less severity shortly afterward. One of the worst cases of chorea I have seen occurred in a boy, aged thirteen, who was carried into the hospital quite unable to stand; the head was thrown back, his tongue was protruding from his mouth, and was almost bitten in half with the movement of his teeth; there were incessant involuntary movements of almost the whole muscular system, and the respiration was greatly embarrassed, especially the act of expiration. He would take several short rapid inspirations, and then with a great effort a long expiratory one; he was almost unable to swallow, great choking being produced on any attempt at deglutition. The pupils were widely dilated, the face pale, and the child was more or less unconscious, with high fever. The day after admission the condition became worse, and acute rheumatism set in in his knees and ankles. Within a few hours there was both endocarditis and pericarditis. Medical treatment seemed to have no effect, and the child appeared to be dying. As a last resource, dry hot-air baths were ordered. After the first the condition rapidly improved, and the patient left the hospital cured about three weeks later. His temperature when placed in the first bath was 101°. In the bath it went up to 102°, and an hour after it was 100.6°.

"*Epilepsy* appears often much benefited by treatment, in many cases combined with bromide taken internally. Some cases, however, have greatly improved both as to the duration and frequency of the fits with hot-air treatment alone. Some forms of *paralysis*, especially lead palsy and paralysis due to injuries to the nerve-trunks, do well under the treatment. Cases of old-standing paralysis due to central lesions do not improve to the same extent, but these, especially those associated with coldness of the paralyzed limb, are in time benefited, more particularly with respect to the nutrition and warmth of the part. Ménière's disease was in three cases greatly relieved. Chronic *bronchitis* (especially cases associated with Bright's disease and high tension) was greatly relieved, as were also cases of asthma and diabetes. I have found the cough greatly relieved in some cases of phthisis, even during the active stage of the disease, and patients have gained weight and expressed themselves as improved.

"A good deal might be said of the effect of the dry hot air on the *heart;* in fact, it would appear that what has been written on the Schott or Nauheim treatment might very well be applied to this. As probably the therapeutic effect of the saline effervescent baths is one primarily of gentle stimulation to the cutaneous nerves, so here again the application of dry heat is an excellent stimulus to cutaneous nerves and blood-vessels, and many cases of chronic heart disease undoubtedly do very well; indeed, my experience teaches me that cases need rarely, if ever, be refused to account of heart mischief.

"Many of the dry forms of *skin disease*, such as psoriasis and dry eczema, do very well, so also in cases of scleroderma (where the patient has never been known to perspire from the affected regions) the skin becomes accustomed to sweat after persevering with the dry hot air. Chronic ulcers and local inflammatory conditions, such as boils, are cured, as are cases of erythema nodosum.

"It is frequently asked if we should administer the treatment to women during menstruation. The general effect of the heat is to increase the catamenia, and therefore in cases in which this is excessive it would not be desirable. I find that, speaking generally, cases of scanty, and especially of painful, menstruation are benefited by the application of heat to the pelvic regions. Amenorrhœa, especially in young anæmic girls, is an especial indication for treatment at about the time the period is due. It has recently been pointed out that many of the chronic backaches and pelvic pains of women are probably due to rheumatic changes in the pelvic and uterine ligaments and appendages. These are greatly relieved, and often cured, as might be expected, by this form of treatment.

"I must now allude to some cases which were not improved by the treatment.

"*Well-defined Locomotor Ataxy.*—A few cases I have treated did not appear to be altered so far as the lightning pains or the ataxic gait were concerned.

"*Cases of Paralysis Agitans.*—Although there was improvement in the general condition of the patient, and increased strength in the limbs treated, there was no apparent diminution in the movements, either during the process of exposure to heat, or as the result of treatment. To *writer's cramp* the same remarks apply.

"The question of the desirability of treating acute cases of gouty or rheumatic arthritis is a most important one, and I still feel unable to formulate definite opinions upon it. The doubt would seem to be particularly strong while pyrexia, considerable pain, and recent infiltration of the tissues in and around joints are present. The more localized the condition, with these symptoms, the more should I hesitate to predict the result of the first few baths. The immediate result of the treatment in these cases is sometimes to disseminate the inflammatory process and convert what was at first a local arthritis into a general one, with the consequence that patient and doctor became alarmed and the treatment is stopped. If treatment be persevered with, and often if in the first instance heat was only applied to one limb, then a whole bath is administered when the condition has become general, the disease rapidly subsides; but the possibility of such an exacerbation of symptoms must be borne in mind from the commencement. A similar result is commonly met with in acute gout with great tumefaction and excruciating pain in one joint. If the heat process be applied to this joint it will soon relieve the symptoms, swelling will subside, and pain disappear. Probably, however, the same condition (even sometimes more acute) will appear within a few hours or during the next day in the corresponding part of the opposite limb. This, of course, frequently happens in cases of acute gout when treated by drugs, but the likelihood of its occurrence after the heat bath must not be overlooked." (SIBLEY.)

Another author states:

"To give a fair idea of the time needed and the results obtained we append a few cases taken at random:

"1. Woman, aged fifty-two, chronic articular rheumatism, duration twenty-two years. Locomotion difficult for twenty years. Twenty-one treatments were given in three weeks, at the end of which she could walk and had painless use and control of all voluntary muscles.

"2. Woman, aged fifty, had stiff wrist, exuberant callus and fibrous adhesions of radius and ulna from old Colles' fracture. Four treatments in arm machine at 340° F. completely restored motions of wrist.

"3. Woman, aged sixty, neuralgia and chronic interstitial nephritis. Inversion of both feet. Severe burning sensation in soles of the feet. Ten treatments relieved pain of feet so that she could walk normally.

"4. Sciatica of two months duration in patient aged thirty-nine. Completely cured in ten treatments.

"5. Woman, aged fifty-two, rheumatic gout, duration eight years, helpless for five years. Treatments daily for two months, after which she was able to walk without pain.

"6. Woman, aged thirty-eight, gout, duration three years. Stiffness and tophi in small joints. Complete loss of power in the quadriceps extensor of the left thigh after the leg was brought to a right angle; muscles of the thigh very much atrophied. Passive motion of the knee-joint good. After four weeks of treatment the patient was able to partially extend her legs and walk a few rods without the aid of her cane. Chronic gout is much more resistant to treatment than rheumatism, but yields in time. This case is still under observation.

"7. Mrs. J. B., widow, aged thirty-eight. Diagnosis, arthritis deformans, duration about twenty-five years, including an attack of rheumatic synovitis of the knee in her thirteenth year, though the disease did not really begin until five years later, one year after her marriage. Helpless eight years. Patient is fairly well nourished; heart and lungs normal; digestion good; bowels irregular. Partial ankylosis of both shoulders, dorsal and cervical vertebræ. Complete ankylosis of the elbows, wrists, hips, and knee-joints. The fingers of both hands displaced toward the ulnar side of the hand and quite immovable. The legs were flexed upon the thighs and the forearms on the arms.

"*Treatment.*—The lower limbs were straightened under anæsthesia, and the patient subjected to daily hot-air treatment for two months; sometimes the whole body, and at others only the limbs being put into the apparatus. A sedative was given at night.

"*Results.*—Great improvement in the movements of all the limbs. Patient able to turn her head, flex her fingers, legs, elbows, and hips. Can walk a few steps without crutches, put her eye-glasses on, and many other things that were impossible when first seen. The hæmoglobinometer showed sixty-seven per cent. hæmoglobin at the end of this time, so treatment has been discontinued until the autumn.

"8. Woman, aged twenty-three, subacute articular rheumatism of one month's duration. Stiffness and crepitation in both knees and one wrist. Ten treatments effected complete cure.

"9. Woman, aged twenty-two, posterior dislocation of radius and ulnar, with fracture of inner condyle of humerus. Fibrous ankylosis on inner side of humerus. Treatment: anæsthesia, adhesions broken, resetting. Hot-air treatment daily for six weeks. Result: absorption of callus and moderate motion of elbow regained.

"10. Woman, aged thirty-two, acute pleuritis of ten hours' duration. One treatment completely relieved patient and caused disappearance of friction sounds.

"11. Woman, aged thirty-eight, fibrous ankylosis of knee from an old pyæmic joint. Duration one year. Right knee fifteen and one-half inches in circumference, three and one-half inches from the table, with the patient on her back and limb as straight as possible. Patella absolutely fixed and very difficult to outline. Very slight movement of the joint. The adhesion had been broken down six times without much permanent good, and resulting in terrible inflammatory reaction. After four applications of hot air the adhesions were broken down under anæsthesia, and as soon as the patient came out of the ether her leg was placed in the hot-air machine and subjected to 312° F. for one hour. The pain was almost immediately relieved. Later the leg was placed in a splint to keep it straight, and when examined the next morning there was positively no inflammatory reaction. In ten days the patient walked out of the hospital with the aid of a crutch, and has continued to improve since.

"12. Male, married, aged forty-six years; lithæmia; duration about two years. Uric acid found in the blood and urine. No lesion of the joints; extremely nervous; neuralgic pains all over the body and limbs. Daily hot-air baths for two weeks, then three times a week for four weeks. No uric acid in the blood at the last examination." (KESSLER.)

Heat in the Diagnosis of Pus.—Lewin, of Berlin, claims that by the local application of heat we can determine whether or not a local inflammation, as appendicitis, has gone on to suppuration. "If the pus has not formed heat will comfort the patient. If pus is present heat will so increase the pain that a diagnosis of suppuration can be made with confidence."

"In cases of swelling of the knee, rheumatic or otherwise, fixation and heat usually give relief, but if pus is present pain is augmented and becomes intolerable." Lewin has tested this action of heat "in a number of cases sufficient to assure him of its diagnostic significance," and cites ten cases of appendicitis in which hot compresses were ap-

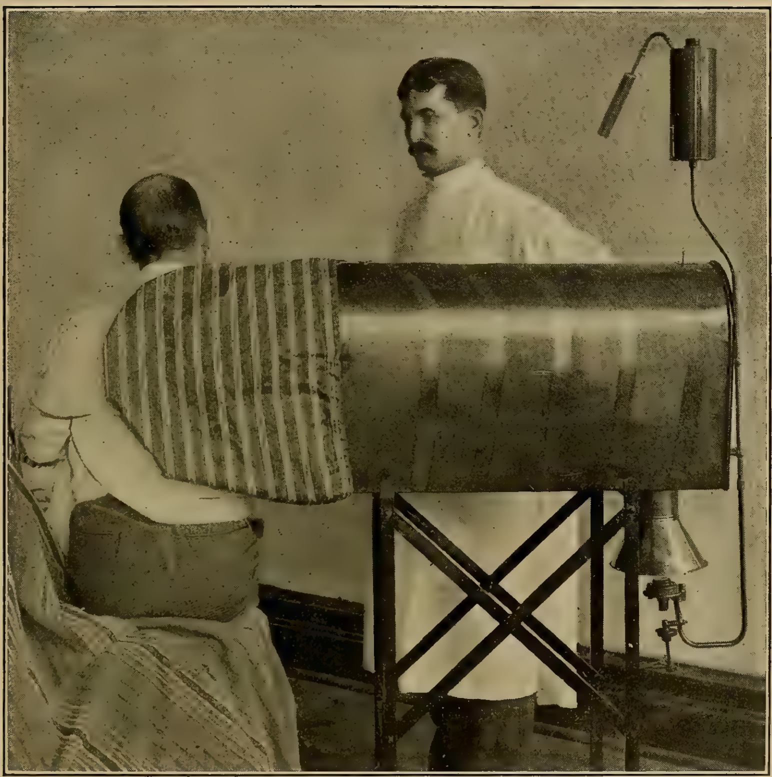

PLATE 263.—Application of dry heat to right shoulder of patient. Canvas sleeve fitted to conduct heat to the local part.

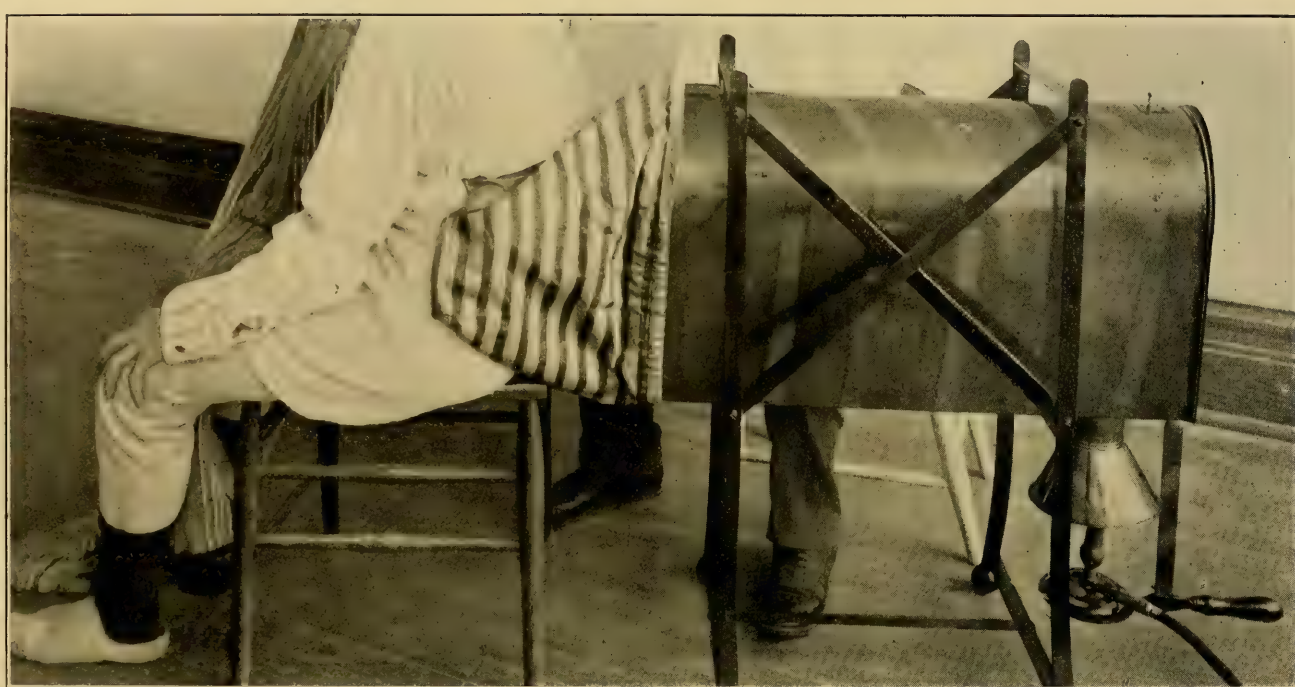

Plate 264.—Showing method of application to sacral region as indicated in lumbago, etc. For either renal or muscular affections higher up attach the canvas hood similarly, but at the level of the affected parts.

Plate 265.—Showing special attachment of hood around right hip for treatment of this joint. By reversing the attachment the left hip can be treated in the same manner.

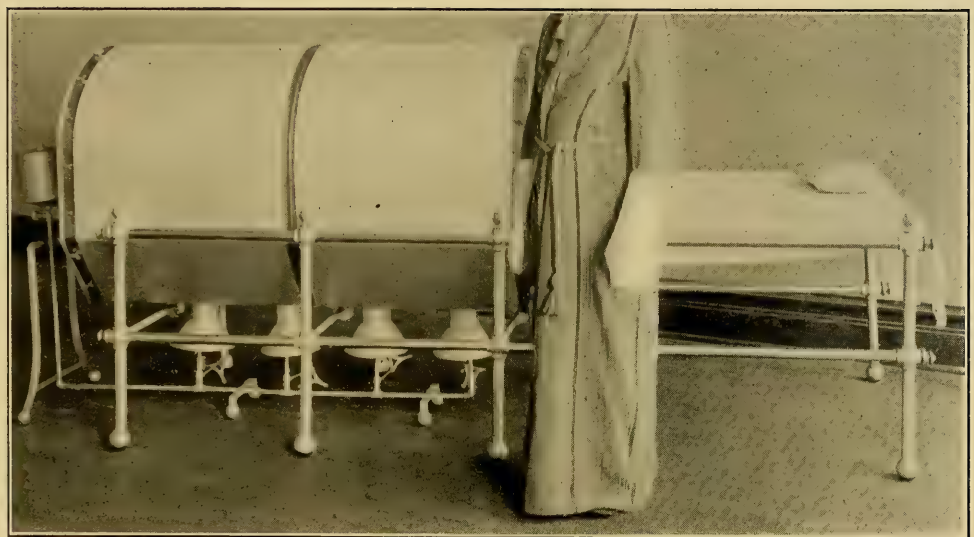

PLATE 266 —Showing patient with hands protected ready to lie on the platform of the Betz Body Apparatus and take a general Hot-Air Bath.

plied for two hours each. Eight were benefited, but two had marked increase of pain and terminated fatally. In a case of perimetritis with aggravation instead of the usual relief from heat a large quantity of pus was later discharged from the vagina. Sphor of Frankfort cites fifteen cases of appendicitis in which the reaction to local heat confirms this conclusion. In the use of hot-air apparatus as well as the common routines of heat this possible explanation of non-relief should be kept in mind, and the presence of pus excluded before going on with the treatment.

Hot-Air Apparatus for Use in Bed.—According to Friedlænder of Wiesbaden in his classical review of all forms of baths the "Sweat Bath in Bed" occupies an intermediate place between the modern Dry Hot-air apparatus and hot vapor cabinets. A satisfactory means of administering in bed a general hot-air bath of from 180° to 300° F. is the portable Hot-Air Apparatus of Dr. Nöel. Higher degrees can be obtained if desired, but are rarely indicated. The unit of the apparatus is a neat zinc-lined wooden box a foot long and five inches wide and deep, in which are placed when heated the two stones which form the source of heat for the patient. These stones are a baked mass of clay, metals, and salts, ground together and made into a brick which is enamelled on every surface except the face from which heat is to be directed to the patient. The composition of the bricks gives them certain properties. They are very hygroscopic and absorb moisture to a great degree; they retain heat for three hours, and they will never wear out. A set of four or six units forms the complete apparatus.

In addition to the stones each box is provided with a metallic case for medicated vapor-baths when moist heat is desired instead of dry, and a screen of brass wire retains the contents of the box and protects the patient from contact with the heated bricks. At the suggestion of the elder Charcot a magnet has been incorporated with the device so that in its complete form the therapeutic result is of a complex nature. The heating of the two dissimilar metals sets up a thermo-electric field into which the magneto-electric and thermal factors bring a combined benefit to the patient which exceeds the action of high temperature alone. Each box weighs twelve pounds, is easily portable, and in outward appearance resembles a small hand galvanic battery.

Method of Use.—Over the mattress of any ordinary bed, couch, or cot lay a rubber sheet. On this spread the regular linen-sheet. On any stove, gas-range, or heater heat the bricks to suit. They can be given a temperature of 800° F. Then place them in the boxes with the unpainted side facing outward. Insert the screens, place one pair of the units on opposite sides of the bed level with the knees and the other pair level with the middle of the trunk. Now have the nude patient get into the bed and recline comfortably in the middle space between the boxes, which are removed from the tissues about ten inches on each side. Then fix between each pair of boxes the bent reeds which form an arch over the patient to support the bed-clothes and also keep the entire apparatus in position during treatment. Draw over all the outer sheet and quilt which retain the hot air in the chamber below the neck. The patient's head remains in the free air of the room the same as in treatment in a cabinet.

Note the condition of the pulse as the treatment begins. Increasing the heat to any sufficient degree is merely a matter of time and keeping plenty of covers closely fitted over the patient. Reducing the heat at any time is merely a matter of lessening the covers and of admitting a circulation of outside air. The regulation of the dose is governed by the state of the pulse, sense of benefit, tolerance of the patient, and freedom from the familiar symptoms of distress associated with an over-dose of high-intensity heat. Cool the head as the comfort of any case requires, and as taught previously.

In from fifteen minutes to half an hour, according to the indications of the case, the effect on the patient, and the responsiveness of the tissues, remove the boxes, cover the patient comfortably, and let him rest in the gradually cooling heat for fifteen or twenty minutes. Then have the nurse quickly withdraw the old sheets and rubber protective, and replace them with a pair of fresh warm sheets. Let the patient enjoy the comfort of these for a quarter-hour or so, when he is ready for the selected after-treatment.

The after-treatment may be therapeutic to meet indications, or may be directed to simply restoring the circulation to normal with the least delay. A practitioner will be governed largely by his resources in this matter. A full regular massage treatment is usual in institutions using this apparatus. General faradization, any local or general application of the sinusoidal current, or central galvanization, can be administered while the patient is still in bed and cooling from the bath. Douches may be given. An alcohol rub, or a rub with a mixture of alcohol and camphor, or the addition of a few drops of tincture of iodine, have important place in the technique. The skin is in a receptive state. Medicated inunctions are valuable and much used by specialists. The intercurrent inhalation of oxygen during the bath is of practical use when indicated. The fact that this application of heat can be made not only in establishments, but at the patient's home in family practice gives it a scope of use that no stationary apparatus possesses and makes the study of its actions far more comprehensive than the usual routine list of chronic hot-air cases. We shall refer to this presently.

The Vapor-Bath with the Nöel Apparatus.—When the skin is dry and the sweat glands act with difficulty, a few initial treatments with moist heat are useful. There are also special indications for a vapor-bath which the physician will meet in practice. After heating the stones as usual place them in the boxes flat with the plain face uppermost and in the space left between them and the side of the box lay the metallic case which has been nearly filled with the selected fluid to be vaporized. The case is so constructed that no liquid can escape till raised to vapor by the heat of the stones. A decoction of elder flowers is commonly used, but any medication can be employed, and when none is needed a simple perfume makes an agreeable addition to the bath. By means of this form of moisture the skin can be started into eliminative action in a very few minutes.

Therapeutic Indications.—To comprehend the scope of action of this portable and convenient apparatus study and modify to suit the case the actions of Turkish and Russian baths, which the device places at the command of the general practitioner in domestic practice in any part of the city or country; the claims made for all forms of Thermal Cabinet baths, which this device can duplicate in effect; the actions of the modern hot-air apparatus, which this portable device can take to the bedside of the patient and treat him in his own bed; and to these add the wet packs and hot fomentations, etc., of domestic hydro-therapy. It is particularly suited to emergency use in family practice and can be procured at a very moderate cost from Dr. Victor Nöel of this city, in whose Balneum it can be subjected to personal test if desired. Lack of space prevents full presentation of clinical matter here. A single extract can be cited, giving in part the experience of a practitioner. We may add that the apparatus will last indefinitely, the originator having one in use for sixteen years which is still as good as new.

"The baths are widely used in the Paris hospitals, and are advocated by the highest medical authorities. Such men as Professors Bouchard, Ball, Germain Sée, Vulpian, Lassègne, Hérard, Pajot Laboulbène, Charcot, Legroux, Lailler, Martineau, etc., have testified to the excellent results derived from this mode of treatment in a variety of pathological conditions. It is mainly in the broad field of the arthritic and infectious diseases that the Nöel bath displays its intrinsic worth. Almost every conceivable form of rheumatic or gouty ailment calls for this mode of treatment, and not only is relief constantly afforded, but most often you will have the satisfaction of effecting a cure. Such will happen, for instance, in recent cases of arthritic neuralgia, no matter what region is affected. We can recommend it in sciatica. In the incomplete, abnormal, insidious forms of rheumatism and gout is the triumph of this bath. Used in conjunction with sulphur, it will help the system to throw off the burden that oppresses it. As to muscular rheumatism, it always comes within the scope of the bath; no matter how acute, it will do good, and very promptly. I have seen several forms of lumbago and torticollis entirely relieved by one single bath. You will also find that some rebellious forms of mono-articular arthritis, among which gonorrhœis arthritis is conspicuous, yield readily to this treatment. Whenever you can satisfy yourselves that you have to deal with some form of slackening of nutrition —let it be lithæmia, and acid dyscrasia, oxaluria, obesity, biliary or renal colic, or even diabetes—do not hesitate to resort to it. Obesity it will control, if persistently used, not, as is the mistaken belief, through the immediate loss of weight, which the bath superinduces, but through the improved nutrition and greater activity of all the functions. I believe that for non-diabetic glycosuria no better remedy can be found.

"This naturally leads me to speak of the indications of the treatment in nephritis. Now, while I have reason to consider the bath devoid of danger, and highly beneficial in all forms of acute, infectious, and toxic nephritis, I should refrain from using it in the later stages of Bright's disease. In the early stages, however, the bath, by relieving the renal congestion and the arterial tension, would appear to be decidedly indicated. In fact, whenever you are confronted by symptoms that point to a state of visceral congestion, especially of the abdominal organs—be it the liver, the kidney, the intestine, the bladder, the uterus—remember that the hot bath affords you a safe and prompt means of relief, such as no other method possesses in the same degree. As a corollary to this indication, you will do well to remember that most of the nervous and circulatory disturbances of woman's health at the climacteric easily yield to the regulating influence of the bath. It stands to reason that this is the time when the increased activity of the peripheral circulation, that the anti-spasmodic influence of sudation, and the increased elimination thus created must be particularly grateful to the feminine organism. And it is not unreasonable to suppose that by so relieving the uterine congestion we may possibly avert or retard the development of some lurking growth.

"Now we come to the most important class of infectious diseases, and first in line we find the eruptive fevers. Let me tell you that, in order to speedily bring out a tardy eruption, this bath is unsurpassed. Only you must abstain from ministering it to children below the age of five or six. By giving the bath during the period of eruption, you hasten the whole process, and considerably shorten the duration of disease. But it is especially in combating and preventing the dreaded

Plate 267.—Showing patient recumbent on platform ready to slide into cylinder for the body bath.

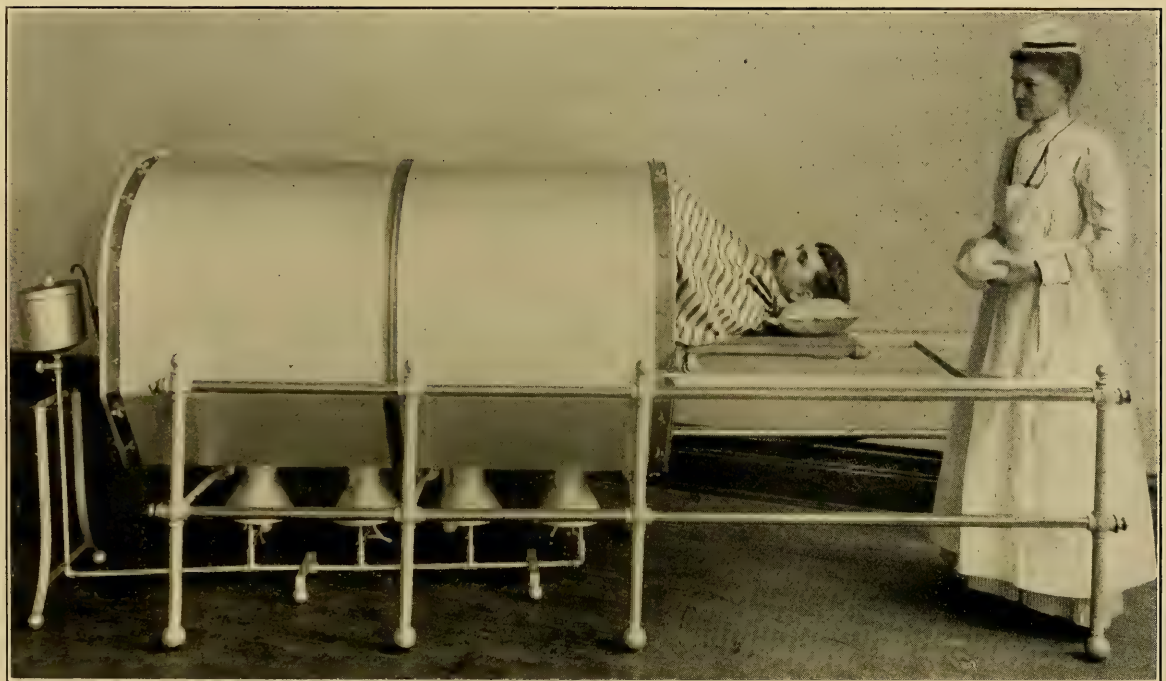

PLATE 268.—Showing patient completely arranged within the body apparatus with canvas hood adjusted to neck and nurse about to apply cold damp cloth to head. The two series of thirty-one Instruction Plates photographed exclusively for this course of clinical teaching illustrate the principles of technic so clearly that, with the aid of the explanatory text, similar treatment can be successfully administered by any practitioner.

Plate 269.—Dr. Hopkins's Apparatus for Hot-Air Applications to the Ear.

"For generating the necessary superheated air the writer prefers the device illustrated. This apparatus is a simple room-heater operating either by gas or oil, and having a funnel-shaped top, which sends the hot air through the canvas sleeve to the ear under treatment.

A few points in the construction of this device are of importance: (1) There must be sufficient draught to secure perfect combustion, without having an excessive draught, which wastes heat, and (2) there must be at least one perforation in the canvas sleeve near the point of contact with the ear, or the dead-air space present will prevent hot air from reaching the ear.

The gauze packing within and over the ear takes up all moisture as rapidly as formed, preventing burning and making the application of very high temperatures easy and without discomfort.

Although it is difficult to introduce currents of hot air to a cavity like the ear, which is open only at one end, if the above-mentioned precautions are observed no difficulty will be experienced. The writer has experimented with a number of more elaborate heating appliances in these cases, but none has given better results than the simple one above described."

post-scarlatinal nephritis that this bath is invaluable. In order to illustrate its heroic action in an equally redoubtable form of nephritis—the puerperal variety—I shall cite the following case, reported by Dr. Lairac. Hotel Dieu, service of Professor Vulpian; case Mme. T.; age, thirty-six; gave birth to twins on January 8, 1885. Ten days later, on leaving the ward, she had a chill, and developed puerperal nephritis, promptly followed by a very severe attack of eclampsia. The convulsions succeeded each other every hour. Under the influence of the hot-air bath the paroxysms rapidly disappeared, and, in spite of the abundant perspiration, the flow of urine, which had been very scanty, became very free. The woman was up and about shortly afterward. Good results have been obtained in the treatment of typhoid fever, and also of typhus. In the former I would use the bath promptly from the start—at all events during the first week, and then during convalescence. Dr. Nöel has had considerable experience with the yellow fever at Panama, and has been fortunate enough in rescuing scores of sufferers, himself included, by the free use of his bath. All the practitioners who have given a trial to that mode of treatment in cholera are loud in its praise. The first symptoms of algidity imperatively call for it. Last, but not least, I would say a few words of the good work of this bath in the treatment of 'la grippe.' I positively know of no better treatment for 'la grippe.' This is also true of the sequelæ of that insidious disease, especially of those rebellious muscular pains, sometimes attended by atrophy, which will persist for months and years after the acute attack. I have seen a great many of these cases, and whenever I could have my way a course of baths and sulphur cured them. I recall the case of a young girl who came under my care three years ago. She had a severe attack of the grippe, which developed into generalized pseudo-rheumatism. Most of the joints were painful, though not swollen, and the muscles of the limbs and trunk were the seat of much pain. There was a great prostration of force; no appetite; no sleep, the fever was moderate. There seemed to be a total lack of response on the part of the nervous system. In spite of all I could do, after two weeks of treatment, the patient suffered more, and was growing weaker. I then prescribed a course of baths, and she promptly recovered.

"I would strongly impress upon your minds one principle, viz.: That the cutaneous surface is the easiest and safest way of exit for any virulent, or venomous, or septic matter, whether introduced into or developed within the organism. Therefore in case of bites from venomous animals, or of wounds from which septic poisoning may be feared, this sweat-bath ought to be immediately resorted to, and persisted in until all danger is passed. Nor is this all. We have it on the best authority that the bath does remarkable work in the treatment of venereal diseases. The experiments made in the Paris hospitals on syphilitic subjects leave very little doubt as to its efficacy. The rapidity with which the bath heals a chancroid is almost incredible. Drs. Martineau and Legroux cite cases in which a course of three baths was all that was necessary to effect a cure. After all this you will find nothing wonderful in the statement that the best results have been obtained in the treatment of almost all forms of cutaneous affections, including rebellious varieties of eczema, and even of lichen. By way of conclusion I would say that a therapeutic agency, for which so much can be claimed, deserves recognition, for therapeutics does not consist entirely in the art of drug prescribing. Aside from drugs there are many helpful things, of which a well-informed and unbiassed physician is always eager to avail himself. This apparatus will enable you to successfully treat an amazing variety of diseased conditions, acute and chronic, from a simple chilling of the body to the most confirmed forms of rheumatism and gout; from a simple boil to the worst forms of blood poisoning. Dr. Nöel's apparatus is handy, safely carried about, and inexpensive. It is the only apparatus that will enable you to give a hot-air or vapor-bath to your patient in his own bed at a moment's notice, without hesitation and loss of precious time; an apparatus that will develop a high temperature, which, however, you can regulate at will; an apparatus from which you can derive powerful effects with perfect safety." (ARNULPHY.)

Studies in Vibration-Therapy

"*One of the most important manipulations of the masseur is Vibration: the hand cannot compete with the machine.*"—(Zander.)

CHAPTER XLIX

VIBRATION-THERAPY

Scientific Massage by Electric Motor Power. Mechanical Apparatus for Concentrating, Intensifying, and giving Therapeutic Dosage to Local or General "Exercise." Methods of Treatment. A "Tissue Oscillator." Clinical Technics in Full. Portable Devices.

To many American physicians the term *Mechanical* Therapeutics has had an empty sound. But as the electric *motor* has wrought an industrial revolution in factories so it is making possible a variety of aids to office practice that must appeal to every physician who tests them. Twenty years ago who thought a *mechanical fan* was a convenience or necessity? The present widespread use of electric fans in summer to set the air in *vibration* is witness to the revolution in popular sentiment which has sprung from the miniature and practical motor. Ten years ago who expected a motor to *fan human tissues into therapeutic vibrations* and to furnish the highest type of scientific massage? To-day the miniature electric-motor drives devices which can place the combustion of local tissues under "forced draught" with the body at rest, and by precisely regulated dosage set muscle fibres at work transforming the applied energy into heat, increased metabolism, and improved physiological function. The term "massage" is so well known that it will occur to every one at the mention of passive exercises for the tissues, but ordinary manual massage compares with the resources of a swift, tireless, and flexible motor (with a score of attachments for precise dosage and an enormous range of effects) as a hand-drill compares with an electric drill, or the horse-car system of 1888 with the electric traction of 1902. These few words should open the reader's mind to the practical possibilities of new apparatus well suited to office methods and of very moderate size and cost. Some must see and feel a thing in order to appreciate it, but what is here said may suggest investigation. A single test will convince. There are three general classes of therapeutic machines which deal with the tissues by means of dosable movements:

1. Those which cover the field of slow Swedish Movements and Mechanical Gymnastics.

2. Those which exercise the tissues of a local part *en masse* in a series of oscillations of regulated stroke and speed, for a prescribed time.

3. Those which do not move the part as a whole but which transmit coarse or fine rapid vibrations (as prescribed) through the softer tissues and vessels by means of motor-driven hammer-strokes upon the surface.

The so-called vapor-massage is another interesting variation of the mechanism, and there are also others which those who desire may look up. A total of about twenty different vibration machines are now to be had, and special applicators for different parts of the body number more than a hundred.

The electric-motor has made this field of therapeutics second only in interest to hydro-therapy and electro-therapy. In particular, it supplements sweat-baths and hot air, the surgery of joints, and all measures that need tissue-change for their completion. To understand the indications for selected *rates of change* in vibrating or oscillating the tissues of any part simply apply the medical judgment gained by study of the effects of all forms of physical exercises—walking, horseback riding, cycling, golfing, rowing, swimming, fencing, swinging clubs, and dumb-bells, etc.—and all passive exercises by resisted movements, Swedish movements, medical gymnastics, every form of massage, and even all the claims of osteopathy. Add to this much of the local work of the faradic current as an anti-congestor, sedative, tonic, or stimulator of inert muscle fibres, and we about cover the range of work adapted to the different motor-driven swift substitutes for former slow and inferior methods. Coming to the practitioner's knowledge for the first time the best apparatus in this branch of technics is a surprise, but he already commands the principles of indications and needs but the revelation of a personal test to realize their value and desire their aid for his own patients. With this fact in view we need repeat none of the familiar physiology, but will note a few features of every-day importance in office practice.

In the *Lancet* of June 2 and 9, 1900, Bennett, of St. George's Hospital, London, contributed an article of great interest and importance on the use of massage in the treatment of all fractures, dislocations, and sprains. It is an article that may be read with advantage in connection with this section of our study. A leading American medical journal cited it at some length with this closing comment:

"These suggestions are by no means entirely new, but few surgeons of repute have given massage so thorough a trial as Bennett has, if indeed they have used it at all. The consensus of those who have used massage in treating fractures, dislocations, and sprains seems to be in its favor. A disadvantage is that it requires a large amount of time on the part of the surgeon, or else he must intrust it to some absolutely reliable assistant, which is not always convenient or possible. If it proves as valuable in the hands of all surgeons, as at present seems likely, *it will be necessary that a large number of intelligent and trustworthy masseurs or nurses be specially instructed in carrying out this work in the wards of our hospitals.*"

The idea that it must require *a large staff of masseurs* fails to take into account the electric motor. When carried out by hand no busy surgeon will think tedious manual massage within his dignity or proper function. We cite this extract here to emphasize the fact that with an improved vibration apparatus this work becomes an altogether different thing and can be carried out by the surgeon or his regular assistant with no impairment of dignity and with a minimum of time. The length of the séance can be reduced to a third. The benefits can be correspondingly increased.

Another point: pelvic massage (in gynecology) has its brilliant advocates and they report wonderful results, but when practitioners must supply the skilled technic with their own fingers the method has no value to the majority. But special applicators (motor-driven) give practical value and office convenience to what otherwise is impractical. Nearly the same is true of certain rectal and prostatic conditions in the male. Special applicators and a mechanical energy obtain in a few moments the best results of any form of massage. The séance is short; no third party—no non-medical masseur—is required. Limited and special massage of certain parts of the body, the face, for instance, is seldom prescribed or attempted by the physician. In this city most of this work is in the hands of people who rank with the manicure instead of the physician or surgeon. The motor-driven instrument brings it within the province of the regular practitioner, and once started the work should add a great deal to office earnings. Have you ever read Morrell's tribute to a little motor device that uses interrupted air-pressures to produce massage effects? It is a study in the value of posting up on modern therapeutic apparatus. We will cite part of it:

"Did you ever take a nervous, whining, sick baby, strip it to the velvet, put it in the centre of a big bed and see it coo and kick the air and get better every minute? There is a great army of invalids suffering from inactivity of the organs of the body, especially the skin and its wonderful system. Their tissues need to kick up and get the air and not feed patent medicine vendors. Massage will do them good, but the drawback has been the great inconvenience and expense attached to its administration. How can we make massage *a physician's method* instead of a nurse's method? That is the question.

"The twentieth-century magician, electricity, has solved the question, and the electric-motor does in a simple and satisfactory manner what has heretofore been done only by the most perfectly trained masseur. It is a very simple, plain-looking machine, *but it is almost human in the way it takes hold of the skin and shakes it, and pats it, and rubs it, and beats it, and drops it with a little snap that is highly pleasing to the patient and wonderfully invigorating to the skin and other organs.* An old German who had received a treatment for facial paralysis, as he rose from the chair and examined the little apparatus, held up his hands and exclaimed: '*Ach, Gott, das ist wunderschoen!*' He was not far out of the way. It is wonderful, and only the beginning of a line of work that will have great influence for good in medicine.

"The clinical purpose of this method of massage (which uses compressed air as the medium of application instead of a hammer) is to vibrate, agitate, rub, stretch, or, in a single word, massage the skin and underlying tissues. So penetrating is the vibration that the periosteum and bone-cells are brought under the action. The nerve-centres are stimulated and greater activity is manifest in all the organs of the body. The inactive glands of the skin are restored to activity and facial blemishes are carried off by the increased blood supply. Wasted tissues are rebuilt and sunken places filled with healthy tissue, and the stomach, liver, and kidneys take on new life and carry on their normal functions in a satisfactory manner. The apparatus for the application of pneuma-massage is exceedingly simple and consists of a small motor, a massage pump, and a set of cup applicators. The pump has three valvular actions:

"1. The first is that of pressure. It forces a column of air against the part, like the tapping of a hammer. It has an almost human touch of great delicacy.

"2. The second is an alternating action that gives a vibratory effect, shaking the skin up and down from 250 to 10,000 times per minute, depending upon the speed of the motor.

"3. The third is that of suction or dry cupping. The extent and duration of the vacuum is under the control of the operator, who can instantly relieve the pressure by raising his finger even when the motor is at its maximum speed.

"It will be seen that all the movements of the skilled masseur can be made by the pneuma-massage pump. The cups can be made of any material, but glass is preferable for the reason that you can always see what you are doing and the smooth edges fit the parts. These cups can be made in all sizes, about six being all that are needed for general work. If desired, the galvanic or galvano-faradic current

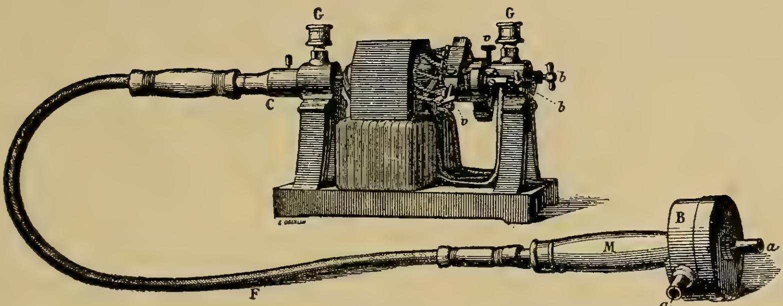

PLATE 270.—A Motor-Massage Vibration Apparatus. The various "applicators" attach in *a* or *a* in the rotating device at the end of the flexible handle running from the electric motor as shown in the figure. For further description see Plate 271.

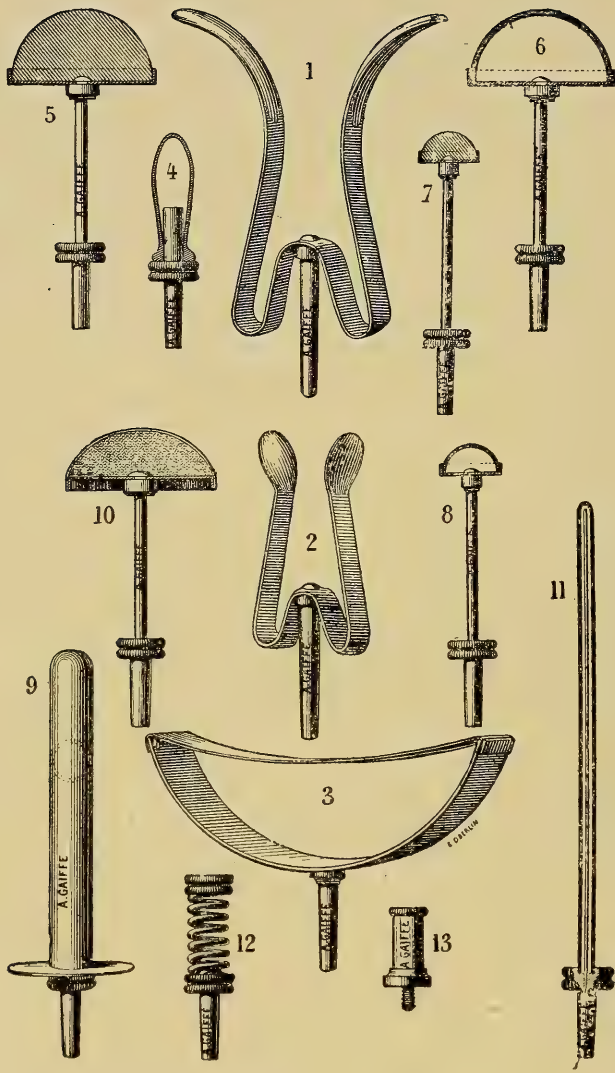

PLATE 271.—In the previous cut is shown the compact apparatus for motor-mechanical massage made by a manufacturer in Paris. At the end of the flexible handle is seen the rotating device (enclosed in case for protection) which imparts the vibratory movements to the selected applicator. The set of applicators furnished with this apparatus are identified by the numbers, as follows: 1. Spring applicator for throat; 2. Spring applicator for bridge of nose; 3. Band for frontal region; 4. Applicator for ear with cap of soft rubber; 5. General applicator of hard rubber; 6. Same in hollow rubber; 7. Local applicator of hard rubber; 8. Same in hollow rubber; 9. Vaginal or rectal applicator; 10. Vaginal applicator for tampon; 11. Intra-uterine applicator; 12. Spiral intermediary spring for use with all applicators to modify action. Many other applicators are made. Stems of various sizes serve for the interior of nose and ear: for mucous membranes a cotton-wrapped applicator carries medicated solutions when desired: a special attachment also conducts electric currents to combine with vibration when desired. These various applicators bear the same relation to vibratory apparatus that electrodes bear to medical batteries, and furnish an almost equally various means of treatment.

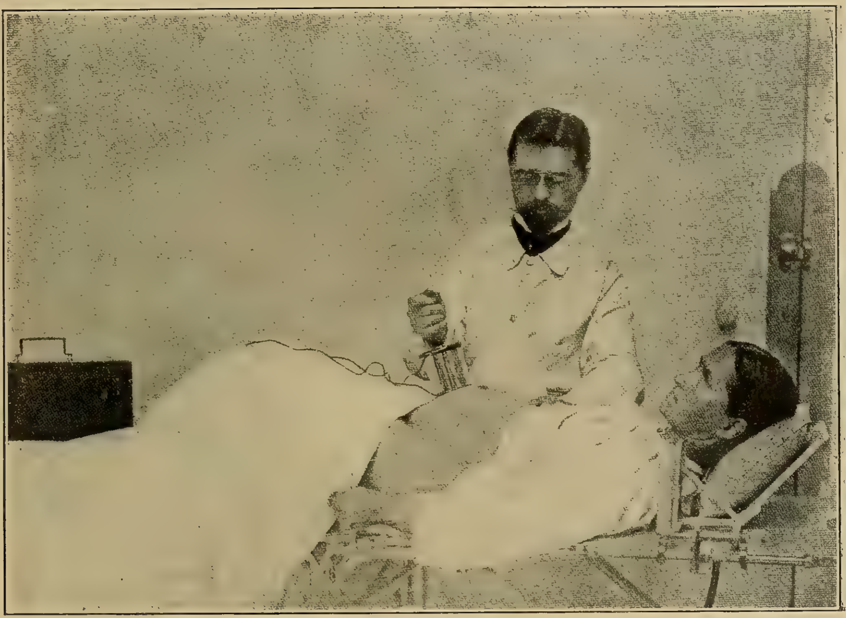

PLATE 272.—Local Treatment of Abdomen by a French Vibration Apparatus.

PLATE 273.—First Instruction Plate of this Vibration Series shows the Motor hung on a jointed frame attached to wall at head of massage table with bank of lamps as controller of the street current which runs the motor. The physician is seated on the edge of the table testing the applicator on his hand preparatory to beginning the series of self-teaching tests described in our clinical instruction. A regular rheostat is preferable to the lamps here shown.

It is to be understood that the therapeutic principles taught in this series of plates apply to other makes of apparatus as well as the one illustrated, which is used because it was available for the photographs, and without discriminating against others.

can be given at the same time by specially prepared electrodes, and it requires less current to accomplish results when used in connection with pneuma-massage. The general purpose of pneuma-massage is to induce activity in the skin and organs of the body. It has a wider field than manual massage, because of the deeper penetration of the vibratory waves. No human operator can compete with it or accomplish what it does. And last but not least, it is very pleasant to the patient and its effects are almost instantaneous, the general systemic tonicity being equal to that resulting from the application of the static breeze, with the added advantage that the effect is of much longer duration."

Experience has shown that regular muscular exercises with progressive exertion not only develop and strengthen the muscles, but eliminate morbid products from the tissues, energize the nervous system, accelerate the circulation of blood and lymph, and improve the functions of many organs. It is necessary, however, to base the exercises on physiological laws, and to be able to modify their therapeutic actions according to individual needs. A dosable mechanism is required. Scientific apparatus affording mechanico-medical effects fall mainly into three classes:

1. Those set in motion by the muscular power of the patient.
2. Those operated by motor-power.
3. Those combining motor-power with graduated resistances or tension on the part of the patient.

The Tissue Oscillator belongs to the second and third classes. While vibration is the most important of all manipulations in massage, yet it must be the most neglected, for no human machine can perform the labor of efficient applications by hand. In the development of Zander's system he gave special attention to vibratory apparatus and placed their employment on a scientific basis. "The vibrating mechanism, brought into contact with the soft tissues of the body, exercises on these an effect of *rapidly alternating expansion* and *pressure*. This accelerates the circulation in the capillaries and lymph-vessels, increases absorption and causes morbid infiltration of the tissues to disappear." Of still greater importance are the influence on the heart and blood-pressure. The researches of Hasebroek established the following results of vibrations:

"Lowering of the pulse rate.
"Improved tone of the cardiac muscles.
"Vasomotor increase of arterial tension.
"Increase of blood-pressure.
"Increased excretion of carbonic acid.
"Vibrations facilitate the peripheral circulation and improve the

nutrition of the muscles by stimulating the heart to a greater activity and by promoting (in valvular diseases) the compensatory hypertrophy so beneficial in these cases. They constitute an indispensable auxiliary to other physical methods of treatment. The essence of the treatment of heart diseases by mechano-therapy is:

"1. The acceleration of the peripheral circulation caused by the mechanical actions on veins and capillaries.

"2. The aid to the action of the heart rendered by lowering the arterial tension, either by reflex dilatation of the capillaries or by diverting a greater quantity of blood to the muscles exercised. The diminution of resistance acts in a measure as a cardiac sedative.

"3. The acceleration of the pulmonic circulation by the increased respiratory action which accompanies the exercise and which reacts beneficially upon the general system of the patient."

The great Zander system of mechanical apparatus with its seventy and more machines for all forms of active and passive exercise and Swedish movements is the prototype and leader in this field. But the truly magnificent equipment developed by Dr. Gustav Zander of Stockholm has far outgrown a private office. It demands the space of an institution; and in Europe more than a hundred of the bath resorts are fitted with Zander's contributions to scientific Mechanico-Therapeutics. The first visit of any educated physician to inspect the workings of this apparatus will excite astonishment and admiration and lead him to at once grasp the value of modified devices which can be used in his own office. The great aim of designers is to supply a tireless and adjustable (dosable) instrument suited to professional use which can substitute for the easily tired and variable muscular energy of human hands. It is obvious that an instrumental means of securing effects under direct medical technique will be for the patient as well as physician an immeasurable advance on laborious ways of old. This is the great point. Improved results in less time is another. Instrumental operative manipulation by the skilled practitioner proposes to do more for the patient in ten minutes than the average and irresponsible masseur does in an hour. Let us now study a selected few of these aids to office practice.

The vibration apparatus illustrated in the next series of Instruction Plates consists of a small dental motor run either by the street current or a portable battery of cells, a rheostat for current control, and an applicator which is connected to the motor by a flexible handle like that used by dentists on revolving drills. The applicator itself is a small thin plaque of vulcanite for direct contact with the skin or over thin clothing, and on this plaque a motor-driven hammer strikes a series of regulated blows which transmit vibratory impulses to the tissues. The rate and force of the blows may be finely adjusted to all parts of the body. The maximum is about 4,000 impulses per minute. The effect is a powerful and very agreeable stimulus to skin, blood-vessels, muscle fibres, lymphatics, and venous circulation. We know of nothing more closely comparable to it than an extremely skilled "general faradization," but with the difference that it is neutral and bland on the most irritable skin, while an electric-current on such a skin will bite sharply and be disagreeable. Moreover, no wet electrode is used and diaphoretic effects can be set up when indicated. The wave impulse of the rapid resilient strokes seems to penetrate far into the tissues and has a power to contract muscles when applied to motor-points that again suggests faradization. Nevertheless there is no electricity in the application, and the only service of the current is to run the motor.

Great improvement in the hammer device has recently taken place and some of the defects of earlier models have been removed. It is essentially an instrument to see and try. A chapter on its merits would have less convincing force than two minutes of the applicator on the spine. It is very important to state in respect to all mechanical devices covered by this section that the teachings of the author apply only to high-grade apparatus and cannot vouchsafe for inferior workmanship. At the Paris Exposition in 1900 there were exhibited more than a dozen different Vibrators. How many designs there are now in this country and Europe we cannot say. But a careful selection is necessary. Some operate on a defective mechanical principle; some involve a crude construction of a good idea; some have had temporary defects that time will eliminate without doubt. An instrument that may spatter oil on the patient's garments; that may pinch the skin on certain pressures; that subjects the arm of the operator to fatiguing strain; or may, by the breaking of a pivot, let fly a hammer-head like a bullet from a gun, should be avoided. An approved instrument will have none of these needless faults and will secure the desired results with cleanliness, comfort, and safety to both operator and patient.

Technics of a Vibration Instrument.—Let us now begin a personal clinic with an electric-motor-driven massage instrument designed to relieve the hand of the masseur and concentrate an hour of manual work into ten or fifteen minutes of professional treatment—to reclaim an important therapeutic technic from non-medical manipulation and place it where it belongs with the practitioner or his assistant. Begin with a series of tests of action on your own tissues to acquire technic, dose regulation, pressure tactics, labile system, and familiarity with sensory, muscular, and physical effects. Dosage depends on rate of speed, degree of pressure upon the hammer and upon the tissues, and the rate of labile change in the situation of the instrument. It is especially necessary to note the effect of deficient soft parts under the hammer. Bony prominences are not adapted to massage, which is suited chiefly to deal with vascular soft parts and act on muscle fibres, blood-vessels, organs, and nerve supply.

Connect up the vibrator with a source of current that will run the motor. In these Instruction Plates the Edison street current is used. A primary or small storage battery may be employed if no street supply exists, but these are less satisfactory and much more trouble. A rheostat is needed to regulate the speed of the motor. The bank of lamps shown in the Plates serves as a resistance controller, but a regular rheostat such as we use for motors on Static machines is much better. Slip off the outside coat, but first test the action through all other garments. Note how the vibration is transmitted through clothing and tissues in remarkable contrast to the conduction of electric-currents.

1. When all is ready take the handle of the instrument in the right hand as shown in Plate 273, not as you would hold a labile electrode, but more as you would grasp a hammer. Sit on the edge of the massage-table, start the motor into slow action, apply the plaque to the palm of the left hand and test the sensations and physical effects on both surfaces. Vary the pressure and run up the speed from very slow to very rapid and note the rate that is most sedative, most stimulating, etc. Note the difference between the same dosage on the ball of the thumb and on the dorsal surface. Modify dosage to suit the character of the given tissues under the plaque. Compare this intense massage energy with the common manual article. Note its superior "dosability" as well as its regularity of action. Note that it transforms a crude process into a scientific instrument of precision fitted to a physician's office. Promenade the vibrator up the arm and over both surfaces. Note the effects of a strong dosage on motor-points. Some of the action closely parallels certain electric-currents, but is wholly without the cutaneous sharpness of electricity on an irritable skin. It is therefore agreeable to tissues on which a local application of a galvanic or even faradic current for similar effects would be difficult to make. Its employment is in fact almost independent of the condition of the skin under ordinary circumstances. This is one of its many merits that appeals to patients.

2. Next recline upon the table or couch as shown in Plate 274 and test the action of varied doses upon every part of the anterior surface

PLATE 274.—Second Instruction Plate of this Vibration Series, showing practice tests of varied doses on every part of the anterior surface of the chest and abdomen, as taught in our clinical description.

Plate 275.—Third Instruction Plate of Vibration Series, showing practice tests of different doses on spine and muscles of back, as taught in our clinical text.

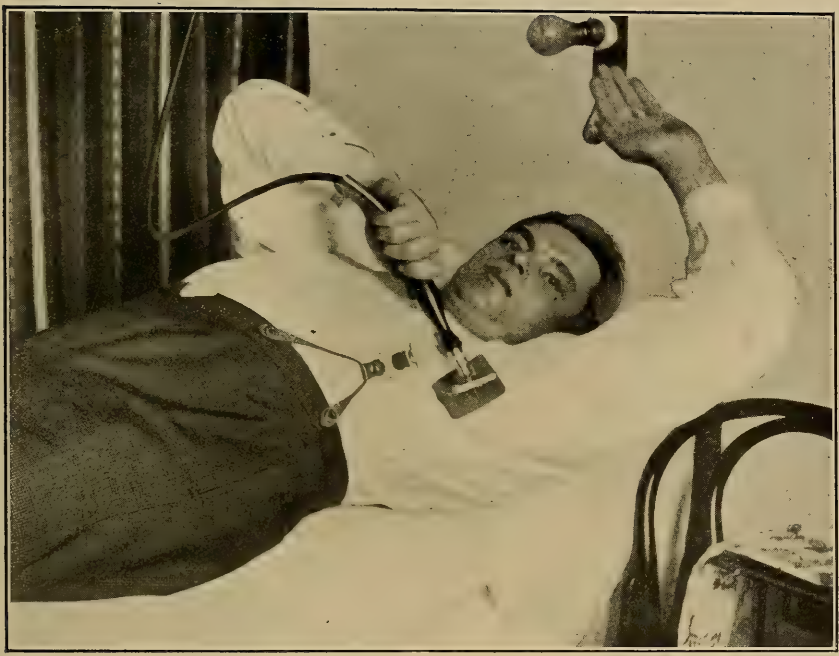

PLATE 276.—Fourth Instruction Plate of Vibration Series, showing practice tests on fields of neck and shoulder commencing in axillary region.

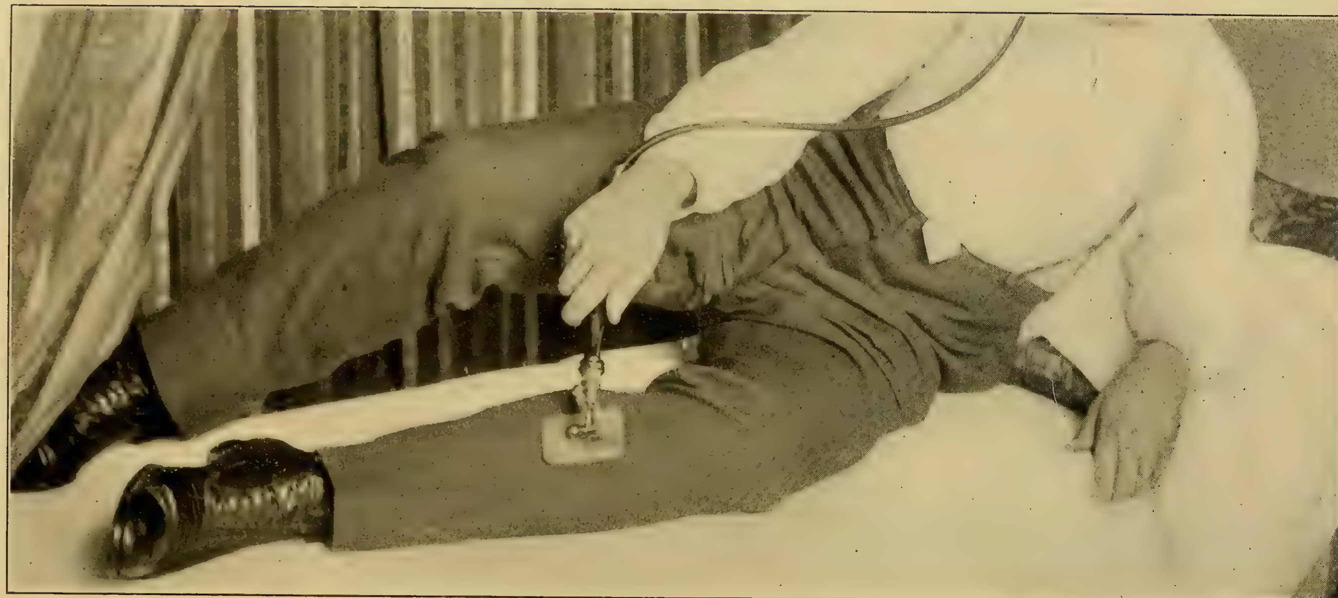

PLATE 277.—Fifth Instruction Plate of Vibration Series, showing practice tests on lower extremities through ordinary clothing with different rates of motor and different pressures on the parts.

of the chest and abdomen. Carry the vibrator over the course of the large intestine and note in this test the fine adaptability of the deep and peculiar massage to functional derangements and to local accumulations of fat. The nutritional action is as useful in chronic constipation and obesity as it is in gout, rheumatism, vascular stasis, etc.

3. Then transfer the vibrator to the back as in Plate 275. Test it up and down the spine and note the restful and tonic result. In equalizing the circulation it also tranquillizes the spinal nerve-centres in a way peculiarly comforting to over-active mental states and emotional conditions. Cross the lumbar region with variations of labile dosage and observe its applicability to lumbago, and its palliative usefulness in Bright's disease. Especially apply the plaque to the upper cervical centres and sides of the neck. Also with modified dosage to the occipital centres and note the sedative effect upon many headaches. Your back furnishes a fine field for study of dosage and special actions. The flexibility of the device enables the operator to test almost all applications upon himself without any assistance whatever.

4. Again turning upon the couch apply the plaque to the axillary region as in Plate 276. Act on the large blood-vessels, tilt up the chin and reach the larynx, the carotid triangles on both sides and muscles of the neck and shoulders. Note especially the cerebral sedation that can be effected in congestive headaches, etc., by influencing the jugulars and carotids in the neck. Apply your experience with electrical applications and bring to bear rational therapeutic principles and a valuable field of work with this instrument will open up.

5. Now pass the vibrator to the lower extremities as in Plate 277, still acting through the clothes. Compare the difference between mechanical vibration on masses of soft tissues, the thigh muscles, the gastrocnemius, and the thinly covered regions of the knee and surface of the tibia. The test supplies the indications for treatment. Once the action is felt by the physician, he needs but little further guide to know when to use it on his patients.

6. Now remove the shoe and stocking and test effects upon the foot as shown in Plate 278. Study all positions of the plaque and all rates of speed and pressure. Its value in cases of sprained ankle and other joints will be apparent at once.

After this series of tests through ordinary clothing test similar actions with close-fitting underwear only covering the part. Many treatments, especially with women patients, may best be given without removal of the underwear, particularly if it is fine and close fitting. It protects the skin from currents of air and will please many better than to be asked to remove their entire clothing. Nevertheless it is often important to reach tissues in the most direct manner. Therefore, study the direct cutaneous effects upon the skin. Note the great intensity of therapeutic action. The circulatory and secretory organs of the skin respond more quickly. Diaphoresis is established, and in general it will be seen that many cases must be stripped for treatment in order to do them the most good. A local part can be exposed and treated and the remainder of the body covered with a sheet or light blanket as needed.

We are now ready to administer a general treatment of rapid mechanical massage to a patient. It is equally adapted to men, women, and children. Have the room warm and comfortable. Have the patient undress as may be needed, recline upon the table, draw over herself the blanket or sheet and announce that she is ready. In the following Instruction Plates the patient is a boy and the sheet is removed for the purpose of demonstration.

7. Ask the patient to rest easily and relax all the muscles. Stand at the side of the couch, take one arm from beneath the blanket and begin at the hand as in Plate 279. Work toward the centres. Regulate the dosage for the varying tissues and make systematic labile movements of the instrument over the entire arm to the neck. With the left hand made supporting pressure to the arm of the patient and flex and posture the arm during the applications so that in each area of local action the muscle-fibres under the vibrator will be relaxed. Do both arms in a similar manner.

8. Pass next to the lower extremities and manipulate them on the same principles from periphery to centres. Avoid exposure of any part except the field under the vibrator. See Plate 280.

9. Along the thigh muscles regulate the pressure and dosage to suit the increased masses of tissue and direct special attention to the points of tenderness, pain, or other symptomatic indications. See Plate 281.

10. Next thoroughly act on the abdominal viscera and walls. See Plate 282. Hold the plaque with deep and special pressure over areas of complaint. Thus comfort a tender ovary, strengthen lax and fatty walls which hardly hold up the flabby viscera of a sedentary and corpulent old person, stir up a sluggish liver, stimulate the functions of the stomach, tone up the solar plexus, subdue an enlarged and tender spleen, expel flatulence, allay nervous irritation, bring the blood to the surface capillaries in anæmic states, and, in a word, meet all local therapeutic indications in the given case. Flex the leg as shown in the plate to relax the abdominal muscles and keep the body protected except under the plaque.

11. Now reverse the patient and promenade the vibrator, as in Plate 283, over the surface of the spine and back. Close a general séance in this way. It is more soothing than any manual massage and leaves the patient rested and refreshed with the treatment. It leaves an irritable nervous system wonderfully quieted. It infuses into a sluggish state a most agreeable stimulation. Imparts to cold conditions a most delightful warmth. Gives freedom of movement and energy to stiffened rheumatic joints. Starts up nutrition. And accelerates metabolism and elimination. Particularly devote stabile pressure for a moment to the nerve-centres of each extremity of the spine. Over the sacrum and at the base of the brain are two important regions to affect.

12. If any myalgic condition affects the muscles of the head and neck apply the vibrator as in Plate 284. Use labile strokes down the course of the muscles to their lower insertions.

13. Aphonia, congestions of the vocal apparatus, pain and tenderness after laryngitis or tonsillitis can be treated as shown in Plate 285. Regulate the dosage and apply the vibrator to the affected regions.

Duration and Frequency of Treatment.—Regulate these according to the indications of the case. For general massage effects allow two minutes to each extremity and three minutes each to the abdomen and spine. For local effects maintain the action till the desired result is obtained. Tests of time required to produce leading effects will speedily instruct the operator on these points.

When local treatment only is in question the rule obtains that stimulating effects need short séances, while sedative effects may need two or three times as long. Acute conditions are more quickly and more permanently relieved than chronic conditions, and chronicity is a greater factor than severity in determining the amount of treatment that may be required.

Treat acute and recent states daily till relieved. Treat chronic cases three times a week except when there exists a local indication for daily treatment. The physician who has had some experience with faradic electricity with modern scientific (not cheap) batteries will need scarcely any suggestions for handling vibration technics beyond making the series of personal tests taught in the foregoing Instruction Plates.

Note that a simple spinal application similar to spinal faradization may be made with the patient sitting on a stool without exposure. A woman with corsets well spread at the back and a thin waist need remove nothing for a sedative-tonic spinal application. A man can readily strip to his undershirt. The effect is very satisfactory.

A Tissue Oscillator.—We now come to one of the most attractive and satisfactory instruments within its scope of action which it has so far been our fortune to meet. It is the Tissue Oscillator of Hanfeld. It is compact, adapted to office practice, simple in technic, and of *self-evident merit.* Theoretical considerations at once become superfluous when the practitioner submits his *own* tissues to the actual experience of treatment. The physiological activities set at work are so apparent that no words are needed to discuss them.

The author first met this instrument in connection with a case of old synovitis of the knee having an acute exacerbation of trouble after a severe walk. The kind and quality of relief resulting from five minutes rapid oscillation of the tissues so impressed the patient and myself that further tests were given the apparatus. The gratifying results form the basis of this section. The essentials of the oscillator are two eccentrics mounted on a standard, adjustable to all desired strokes, and made to revolve as slowly or rapidly as required to produce needed effects. A small electric motor runs it. See Plate 286. The chief applicators are three:

1. A belt for general uses on the body. (See Plates 287 to 293.)
2. A foot-piece. (See Plate 294.)
3. A hand-piece. (See Plates 295 and 296.)

In addition to these direct mechanical applications means are provided for including faradic and other electric currents in the circuit at the wish of the operator. The Instruction Plates render a more detailed description unnecessary.

We will first consider the direct mechanical action of the Tissue Oscillator. It is distinct from either vibration or massage. To be rightly appreciated the action must be felt. The immediate action is localized by the situation and contact of the selected applicator, but oscillatory waves diffuse to greater or less distances in the surrounding soft parts according to the dosage—length and frequency of stroke—and these waves can be felt and seen by any observer.

The work of some drugs must be taken on faith; some eminent men with but a remote acquaintance with electro-therapy regard it as allied to the processes of "suggestion"; it may be open to doubt whether an "absent treatment" by one of our Christian Science friends is doing all its perfect work; but about the work of this Oscillator there is no doubt whatever. It tells its own story of energetic physiological activity to every sense of the patient and leaves no part of its motive to the imagination. Add to this that it demonstrates a wide range of usefulness in practice, does not require entire removal of clothing, makes no other demand on skill than regulation of the

Plate 278.—Sixth Instruction Plate of Vibration Series, showing shoe and stocking removed to permit practice tests on bare tissues. Particularly study the actions around ankle-joint with reference to the treatment of sprains. Learn how to avoid sensitive areas little padded with soft parts, and to regulate the dosage according to the situation of the applicator.

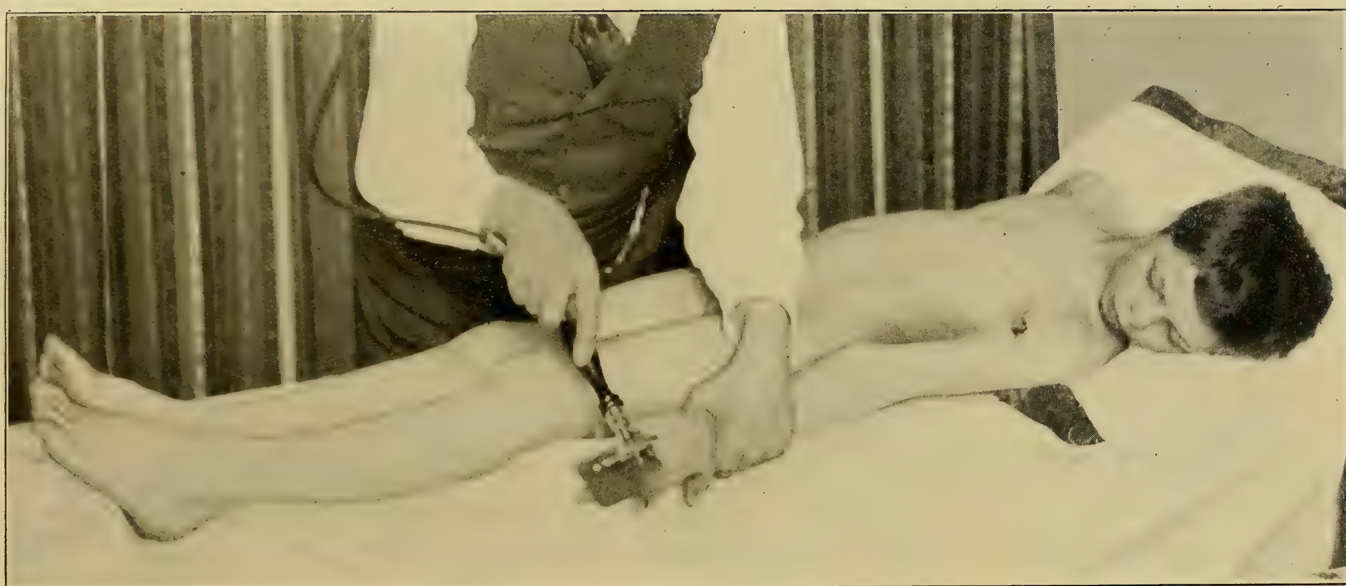

PLATE 279.—Seventh Instruction Plate of Vibration Series, showing patient stripped and on massage table for general treatment to entire body, commencing at one upper extremity as taught in the clinical text. In actual practice the patient is covered with sheet or blanket and no exposure occurs, but the covering is removed in the photograph to better illustrate the technic. For many effects treatment may be equally well given through close-fitting underclothes, but for intimate action upon the cutaneous nerves and blood-vessels the application is best made upon the bared skin.

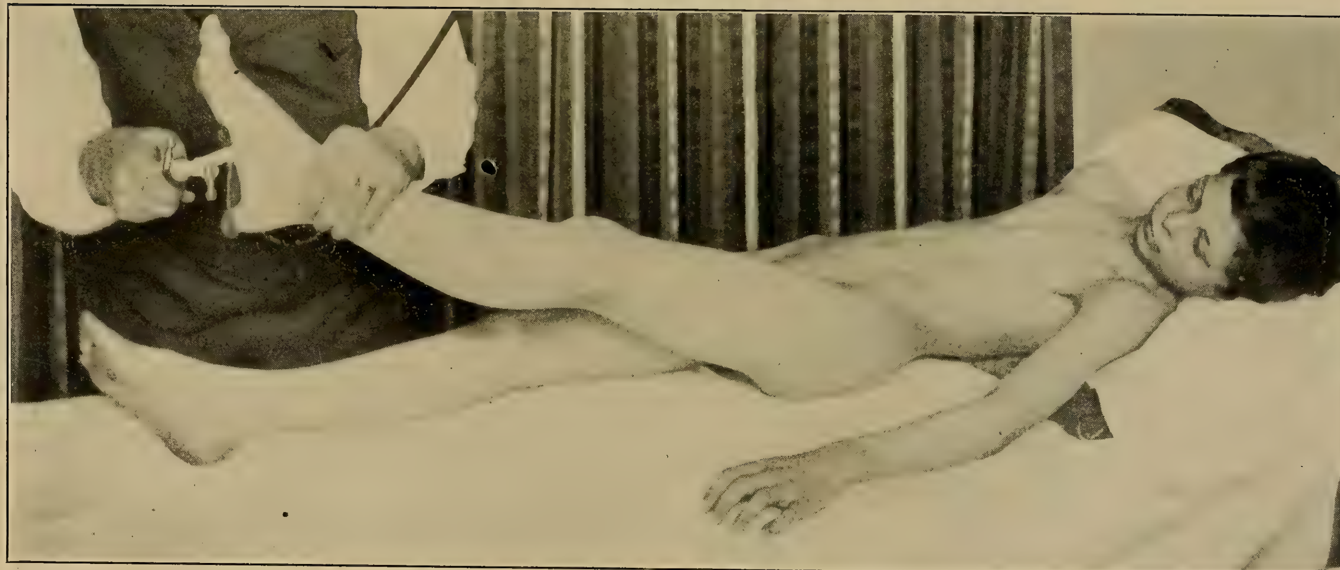

PLATE 280.—Eighth Instruction Plate of Vibration Series, showing motor-massage beginning treatment of the lower extremities at one foot, from which it will proceed upward toward the centre, as seen in the next cut.

PLATE 281.—Ninth Instruction Plate of Vibration Series, showing continuation of the treatment along the lower extremity to thigh. On these thick muscle-masses regulate the pressure to suit the increased mass of tissues and hold the applicator stabile on any points of tenderness or pain, as taught in text.

dose, and takes but an average of five or eight minutes for a séance, and the value of the device will appear.

The physician who has read any treatise on the Zander effects needs no instruction as to the general physiological actions and therapeutic indications of a closely related Oscillator, and space will not be taken to review what should be so well known. Suffice it to say here that whatever else this deft machine may do its main appeal to the physician will be its local action upon tissues—to increase *combustion* in states of excessive inertia or adipose; to increase *nutrition* in states of deficient adipose or oxidation; to give sets of muscle-fibres active work with the system passive; to energize the general circulation; to determine a greater supply of blood to a given part, or to scatter stasis, abate congestion, and dilate the capillaries of the skin; to stimulate the cutaneous nerves, set up the heat of intense tissue-activity, relieve the pains of cold conditions, and when all is done to leave the patient rested, benefited, and refreshed. The many minor effects growing out of the above will develop in practice and need not be dwelt on now.

This Oscillator is in effect a means of inducing *direct local exercise* in the tissues of a part of the body which otherwise would remain inactive or out of balance with the normal energy of the body. As muscular exercises are "*effective means, impossible to substitute,*" for maintaining the equilibrium of the heart, nerves, and organs in a vigorous state, so a means of applying a definite dosage of potential energy by mechanical power to exactly localized regions without a general tax upon other tissues which may not need it is one of the primary requirements of physical therapeutics.

Zander recommends medical exercises (mechano-therapy) for all the valvular lesions and their progressive states, in idiopathic hypertrophy and dilatation from over-work, chronic myocarditis, fatty degeneration, cardiac neuroses, stenocarditis, nervous palpitations, arterio-sclerosis, etc. In diseases of the nervous system vibratory treatment may play an important part. In neurasthenia, irritability, debility, hysteria, insomnia, excitement or depression of mind, in the recovery from neuritis, in neuralgias, as an aid in the treatment of paralysis, wherever the special actions of locally applied mechanical energy are indicated, we may use vibratory and oscillatory apparatus with benefit. Rapid nutritional vibration may be applied to the thorax in such respiratory diseases as need vascular sedation or stimulation, to the larynx in simple laryngitis, and to the frontal and nasal regions in nasal catarrhs.

As an adjunct to regular remedies in anæmia and chlorosis and attendant symptoms such as headache, dyspepsia, constipation, tenderness in the epigastric region, coldness of the extremities, backache, general lassitude, etc., the local actions of the motor-driven high-intensity tissue-work set up by an efficient vibration apparatus will help wonderfully. The immediate sense of warmth resulting from the improved distribution of blood becomes gradually permanent, the general nutrition improves, the liver and bowels take on more competent action, and the general progress toward normal health is accelerated. As a foot-warmer the rapid oscillation of the extremities has few equals. In muscular pains and stiffness of the kinds responding to heat and static counter-irritation—lumbago, myalgias, sciatica of certain forms, local congestions in the muscles of a rheumatic character, etc.—the direct heat under the oscillating belt and the frictional application is one of the most satisfying things that can be offered a patient. The appreciative remarks of patients are also one of the most satisfying things that can come to the physician's ears.

By testing the vibratory effects the practitioner can feel for himself (and need take no one's word) that a regulated dosage has useful place in many unexpected conditions, such, for instance, as chronic intestinal catarrh with diarrhœa, in simple and recent hemorrhoids, in chronic cystitis with atony of the bladder, in a host of local atonies wherever met, in disorders of menstruation and many of the diseases of women. It is almost superfluous to speak of the value of motor-massage and tissue oscillation with regulated dosage in chronic gout and rheumatic conditions; in old cases of synovitis, in sprains, contusions, and local states that a flushing of warm blood through capillary stasis can benefit. We need not seek theoretical reasons to guide us in the prescription in most of these cases nor need the beginner search far and wide to learn the experience of others; simply let him test the physiological actions on every part of his own body and he can ask no further guide to direct practice. This is a great merit of the apparatus and clears hesitation away.

But there are two especial conditions in which motor-mechanico-therapy takes pre-eminence. Many forms of energy will excite muscles to contract and cells to secrete, and enhance oxidation in the tissues, but few means equal and none surpass the direct and forceful action of Hanfeld's Oscillator. Under the heads of *chronic constipation* and *obesity* we will say more on these subjects.

Obesity.—To combine with other rational management of obesity cases we believe that the mechanical action of the Oscillator rounds out the sum of treatment in a manner not surpassed by any other prescription. Far more expressive than our written opinion, however, will be the results of practice. But while the Oscillator can with benefit and entire safety assist corpulent people the degree of relief depends on persistency of treatment. A reasonable expectation of results is wise. Before citing a case let us note the observation of a distinguished European specialist in the bath and gymnastic management of dieted obesity: "Obese persons have every reason to be thankful if we succeed in *diminishing their increase in volume.*"

By the transformation of mechanical energy into tissue work the Oscillator causes a consumption of fat in the soft parts of the body, in the omentum and the covering of the intestines, where it is the greatest inconvenience. After a week or two of primary daily treatment the patient becomes more mobile, more enduring and energetic, gets rid of his troublesome palpitations of the heart, of his shortness of breath, and flatulent distention and various other symptoms. The actual weight lost in pounds may be very little directly due to the Oscillator, but the advantages gained make it of little moment whether the loss is more or less, provided that further increase is arrested.

The following result was obtained by the author without regulation of diet, or aid of sweat-baths, purgatives, salts, mineral waters, or any other treatment except the Oscillator: Mrs. ———, aged fifty, had for several years complained of abdominal fat. Subject to flatulent distention, a neurotic heart, great lack of physical endurance, frequent pain in side, complete dependence on drugs for action of bowels, irregular sleep, etc. Her "high stomach" was a cause of great mortification. Daily treatment with the Oscillator was begun as follows: Half-inch stroke; rapid speed of motor; belt first over lumbar region, then a half-turn bringing belt over side and liver, then turning to bring belt over stomach and gradually slipping it down the abdomen to the symphysis. See Plates 287, 288, 289, 290. At first the séance was limited to three minutes, then five, and later ten minutes, as tolerance to the muscular exercise improved. All symptoms were ameliorated, the trim of the stomach and figure around the waist was greatly improved and the sense of benefit was far more than was shown by the scales. The first week of treatment was rather disturbing than comforting; the second week was beneficial, and the third week witnessed decided results that were very satisfactory. The technic and action is especially adapted to the lax and flabby abdominal wall often so troublesome to old ladies after much child bearing in earlier days.

Chronic Constipation.—In the treatment of ordinary cases of this complaint the general practitioner will derive the greatest satisfaction from the Oscillator. Colombo's experiments on animals in the laboratory of the College of France showed that the mechanical vibrations augment the production of gastric juice, increase the secretion of bile, and develop the muscular tonicity of the abdominal walls, giving increased power to peristalsis. The eccentric stroke of the Oscillator sets up a circular wave which acts both back and front and to the right and left of the immediate contact, and, therefore, enables us to attack adjacent tissues and internal organs which are not directly in the direct line of contact of the belt. Unless there is some persisting and unremoved cause for inaction the results of Oscillatory treatment will please the patient. An example will suffice: (See Plates 287, 288, 289, 290.)

Mrs. ———, aged about forty-nine, no stool without a cathartic; could not remember so far back as to recall when her bowels had acted naturally. Had had several children and now presented a lax and distended abdomen; stools indicated great lack of secretion; very dry, and very difficult to expel. Said it was often like " a bornin' " to her. Had been absolutely dependent on laxatives for ever thirty years. Stopped all medication; made no change in diet or habits; applied belt to lumbar spine, to side, over liver, and to abdomen. Daily séance, gradually extended from three to five and seven minutes. Stroke at first six millimetres; later increased to ten millimetres. Motor speed adjusted to patient's sense of greatest efficiency, which was usually the full rate.

After two days she reported a somewhat dry stool but of fair color and relief. For a week she had irregular actions, giving evidence of a gradual working down of high accumulations, some of which were like black bullets. During the second week she felt great encouragement to persevere without the aid of drugs and remarked evidence of improved flow of bile and intestinal functions. With the third week physiological action seemed to have resumed sway for the first time in her recollection. In color, consistency, odor, thoroughness of excretion, and in all that pertains to normal functionation the result appeared to be complete. Treatment was stopped twenty-six days after her first séance.

Owing to the patient's great interest and delight at her prospect of release from the slavery of pills, salts, etc., my observation of the quality of improvement was particularly close and it deserved notice. During a wide experience with many forms of extra-drug treatment of similar cases, especially referring to my past writings on the good effects of sinusoidal currents of coarse quantity and moderate voltage, I have never seen any other treatment equal the physiological character of the results given by the Tissue Oscillator. It seems to me

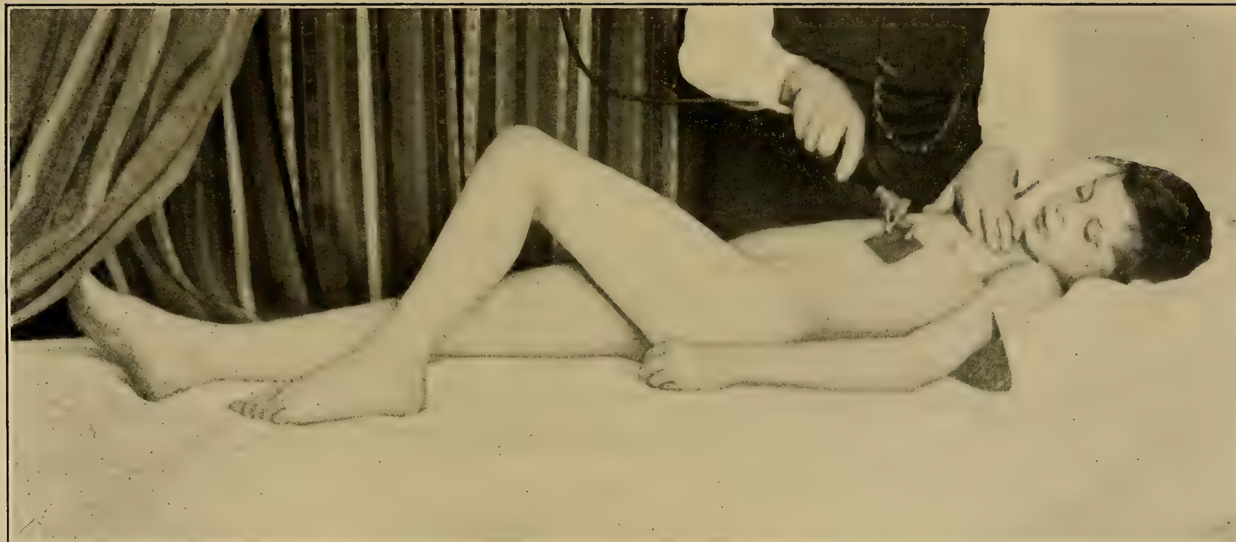

Plate 282.—Tenth Instruction Plate of Vibration Series. Next act thoroughly upon the abdominal viscera and walls, beginning at the upper border of the stomach. Make deep and special pressure with rapid and strong vibration over each area of complaint. Flex the leg or legs to relax the abdominal muscles and keep the body covered except directly under the applicator. Note the great difference in the relation of the physician to this technic of skill and instrumental treatment and the manual labor of tedious hand massage. While a masseur can, of course, assist the physician and apply this treatment, yet it is not more unsuited to medical hands than is the application of a surgical bandage. The skill that is desirable can best be displayed by the competent practitioner.

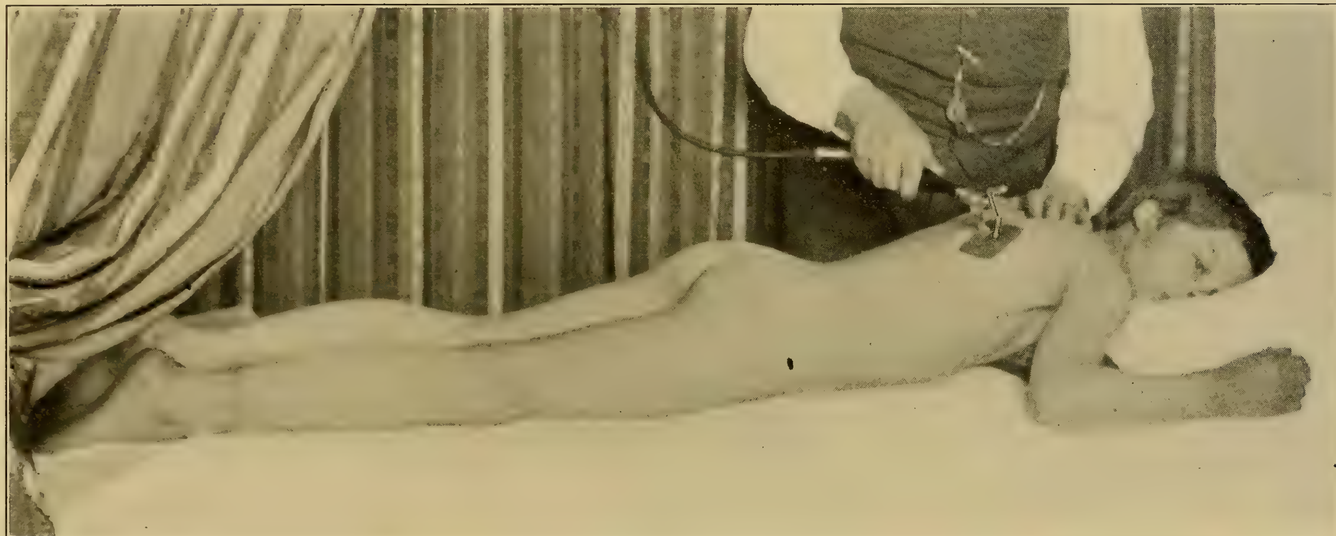

PLATE 283.—Eleventh Instruction Plate of Vibration Series, showing treatment of spine. End a general séance in this way. Promenade the applicator along the spine and over the muscles as taught in the clinical text. This and many of the local applications can also be made with the patient sitting on a stool or chair.

PLATE 284.—Twelfth Instruction Plate of Vibration Series. If any myalgic condition affects the muscles of the head and neck apply the vibrator as shown in this plate, commencing at the upper insertion of the muscles, and making labile movement down the course of the affected fibres. Some external massage can also be administered to the ear, tilting the placque and securing the proper contact. In this plate the sheet covers the patient except on parts being treated.

PLATE 285.—Thirteenth Instruction Plate of Vibration Series, showing application to throat. For aphonia, congestions of the vocal apparatus, pain and tenderness after laryngitis or tonsillitis, regulate the dosage and apply the vibrator over the affected region with slow labile movements as taught in our clinical text. There are many forms of applicators and of motor-massage devices now in the field, and not all can be illustrated in this work, but the principles of practice are here adequately laid down, and may be carried out with any efficient instrument for the purpose. Study the descriptive text in connection with the plates, and a few tests will make plain the treatment of patients.

that this fact alone will appeal to many practitioners. No complete list of diseases and their treatment by the Oscillator is needed here, for the application of the therapeutic principles involved is easily within the general medical judgment, but a few hints may be given to aid the beginner.

Flatulence.—Belt on lumbar and abdominal muscles. Gives splendid results.

Floating Kidney.—Belt as above. Have noted better relief from pain and distress than patient had obtained from any other method in fifteen years' experience.

Scanty Menstruation.—Belt over sacrum and lower parts of the pelvis in front. Also on thighs just below pelvis. Increases the blood supply in the parts.

Commencing Impotence in Male.—Belt on front, side, and back of each thigh just below pelvis; also across front of both thighs with genitals under the belt. French investigators report that all secretions (and spermatazoa) are increased, and it is palpable to the crudest test that warmth and a determination of blood extend to the parts.

Splanchnoptosis.—In his excellent monograph on this condition Robinson cites fourteen predisposing factors and seven specific causes for at least two-thirds of which in their entirety the Oscillator would furnish one of the best correctives. He gives three lines to massage and two lines to electricity in the treatment. In all his non-surgical cases the potent action of the oscillatory exercise on the relaxed skin, abdominal walls, and underlying structures which have lost their contractile elasticity in whole or in part, would appeal more to experienced medical judgment than his inadequate suggestions. Try this method with the belt over all the indicated parts. Its simplicity, convenience, gratification to the patient, and positive effects, easily place it among the first of therapeutic measures in this field. Employ a suitable electric current in alternation.

Palpitation of the Heart.—Functional neuroses dependent on flatulent dyspepsia and reflex causes improve during the treatment of the main indication. In the author's experience palpitation has been entirely removed by the belt application around the trunk for the improvement of digestive functions.

Frontal or Occipital Headaches.—A fine and narrower belt may be applied to either region and very short stroke and very rapid oscillations employed for sedative effects. As a rule congestive states of the head will feel some aggravation from the action after the séance, while opposite states will benefit. Consult indications more carefully about the head than any other part when setting up a mechanical disturbance. Conditions which call for quiet, repose, rest, immobilization, etc., do not call for motor-oscillation. The principle covering contra-indications is simple.

Many have either seen or read of Charcot's vibrating helmet for headaches. The hand applicator will enable the operator to manipulate the head from the eyes and frontal region over the scalp as needed to the occiput and base of the brain, with very similar action to Charcot's helmet. As the author has experienced both methods he can vouch for the similarity.

Revulsive Effects.—Apply the belt and local action on a distant part.

Cold Feet.—Place both ankles in the belt and apply rapid tonic oscillations.

Fibrous Ankylosis of Principal Joints.—Direct application of the belt to the joint affected.

Neuralgias Below the Neck.—Apply belt over seat of pain. Aid by posture which gives best effect during treatment.

General Tonic Exercise.—When no disease exists and in all cases employing the Oscillator for general exercising actions with sedentary people pursue the same plan as described for constipation. It is an excellent local gymnastics with diffused effects. Ten minutes such exercise a day would keep busy sedentary people from the ill-effects of insufficient tissue-change.

Aural Massage.—Specialists in diseases of the ear may not only use the Oscillator for many other actions, but may produce the same vibratory effects of other apparatus by using the hand-piece and making pressure as desired with a single vibrating finger-tip. The technic can extend also over the course of the Eustachian tube and over the pharynx and larynx. A test will demonstrate the action.

Gynecology.—Physicians may take a leaf from the teachings of advocates of extra- and intra-pelvic massage, and apply the required actions by means of the hand or belt. Many claims are made for skilled use of the Oscillator in ovarian and uterine derangements, and the principle of thus treating many non-inflammatory conditions, especially those of venous inertia, is sound. The expert in advanced electro-therapeutics will be struck with the similarity of action between many coil and sinusoidal effects and vibration.

Acute Pains.—Among the acute pains removable by sedative or stimulating oscillation are most of those regularly treated by coil, sinusoidal, or static currents, but dosage and method of application must be suited to the part and to the etiology of the pain. The experienced physician needs no list of technics other than his general command of skill.

Rheumatism.—Muscular and chronic varieties are well treated by this apparatus. Use the belt or hand applicator according to the area and extent of parts requiring contact.

The Face and Scalp.—To improve the nutrition of the scalp or to "massage" the face for various reasons, the hand-piece of the Oscillator is available to the practitioner.

Neuritis.—Vibration and sedative-tonic oscillation both have a place in the treatment of neuritis. During the stages of paralysis and recovery the application will assist other measures with great comfort and satisfaction to the patient.

Paralysis.—What has just been said of neuritis is true of paralytic affections, whether of the curable or incurable class. The final effect will depend on the nature of the case, but the immediate action upon circulation and warmth is excellent.

To continue tabulated directions is unnecessary; we may only say further that almost without exception the treatment elicits expressions of delight from the patient. It is enjoyable during treatment and leaves comfort behind it. This is a not unimportant feature in private practice.

Technics for Treatment.—For the various forms of administration we need three kinds of chairs: a revolving piano stool, a stout cane-seated, high-backed ordinary chair without arms, and a chair with side arms. Have no casters on any of them. Put a pair of rubber tips on the front legs of the second chair; partly to tilt it back a little and partly to keep it from slipping forward under tension.

For treatment with the *belt* have men remove coat and vest. (Plate 286.) If still more active effects are desired have the patient strip to under-clothing. For direct effects to secure the maximum of capillary dilatation and frictional stimulation on the skin, especially of the abdomen and pelvic region, apply the belt on the exposed surface. This will rarely be a very great advantage. For the feet and legs most work can be done through trousers and shoes, but when action with the foot-piece is wanted on the soles of the feet and the shoes interfere take them off. This need rarely be done.

Women patients must have freedom from pressure of corsets about the abdomen when the trunk of the body is treated, but otherwise no special removal of clothing is needed as a rule. Very heavy skirts may at times interfere with some local application, but they can be managed without removal. Management of other parts is about the same as for men. The effects are really best the nearer the skin we place the applicator, but in practice the effect is not seriously impaired by ordinary garments except the corset. It is well to have a thin and loose wrapper to throw around women after they remove their waist and corsets, and especially if they also prefer, as some will, to take off the outer skirt to secure the best effects.

For most treatments between the neck and the knees the patient may best stand, unless special reasons exist for sitting. It is much the best to apply abdominal and lumbar treatment with the patient standing, as the oscillatory waves are then transmitted more generally throughout distant tissues. Have the patient sitting for applications to the head, arms, knees, ankles, and feet, and persons with impaired ability to stand may sit for applications to the trunk also. The Instruction Plates show a suggestive variety of methods.

Length of Stroke.—Each eccentric has a millimetre scale marked on its side. Both must be adjusted to the same distance from the centre of the axis. Loosen the set screw and shift the eccentric as far from centre as will give the length of stroke best suited to do the work in hand. Then shift the other to the same scale. Tighten the set screws of each and the adjustment is complete. The shorter the stroke the finer the vibration or oscillation. For sedative effects the principle of *fine* and *rapid* vibrations is here the same as in the uses of a high-tension coil, as taught in " Elements of Correct Technique." Test the action with the hand-piece on the root of your own nose and the work to be expected of this dosage will be apparent. One millimetre is a very fine stroke. Two millimetres is as coarse as most uses of the hand-piece require. A range next of from four to eight millimetres with the belt will give tonic and circulatory effects without much work upon muscle-fibres. These strokes do not tax endurance or require the gradual development of tolerance in order to avoid fatigue or muscle-soreness after the first treatment of indolent muscles.

A stroke of about ten millimetres is stimulating and excites the muscle-fibres to intense work, according to the speed of the motor The range of stimulating strokes is from eight to sixteen millimetres. These are chiefly employed on thick masses of soft parts, such as the lumbar region, thighs, abdomen, and especially on local deposits of fat. To know just what stroke to use with belt applications make a few tests on your own person, and the subject will require no further reading. Intimately related to the length of stroke and dominating it in securing effects is the rate of speed.

Speed of Oscillator.—The principle is the same as in the uses of slowly or rapidly interrupted electric currents. A slow walk will

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PLATE 286.—The Tissue Oscillator with electric motor behind it on heavy oak base, which must be firmly screwed to the floor in a convenient corner of the office for use. Begin a general tonic treatment with the belt as shown, and gradually slip it down across the lumbar region, then over the liver, abdomen, and spleen in turn, ending with any local application indicated. Pressure of the foot against the edge of the base aids the patient to keep tension on the belt. Steady it with the hands as shown in the figure.

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PLATE 287.—Showing position of patient with belt to lumbar muscles, and operator steadying belt by loose pressure of his hands. With the patient well in line with the shaft the handles will run very steadily without attention, but at times, and when the pull is out of line, a little steadying is needed to check a side-throw. The patient should lean back upon the belt with twenty to thirty pounds pressure to maintain an even tension on it.

TISSUE-OSCILLATOR SERIES.

PLATE 288.—Showing the patient with outer clothing removed, and a side lean upon the belt to act on the region of the liver. Reverse side for spleen. It is useful to place a chair as seen in the photograph to steady the patient in his posture. Dose rate of speed and length of oscillating stroke as taught in the text. All the shiftings required to act on the trunk are made without stopping the motor or relaxing the tension of the belt. Simply turn the body as needed.

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PLATE 289.—The patient in underclothing has completed the body applications, and is now seen with belt over pelvic region. Here a decided effect on the rectal region is obtained, and by turning from side to side and in front the hips and vesical region can be treated in the same manner. Besides other indications, muscular pains and some cases of sciatica are relieved by a regulated dosage. There is a very marked revulsive effect. A counter-irritant action can be induced by direct application to the skin when desired. Steady the even action of the belt by a light pressure of the hands as shown.

set up very gentle circulatory alterations in the tissues. A more rapid walk will quicken the effects. A brisk running gait is an altogether different exercise. So it is with the Oscillator and slow, medium, and quick rates of speed.

A very few conditions need to be treated by a very long stroke at a very slow rate of speed. It wastes time as a rule. Sedative effects require the most rapid speed of the motor, and a proper motor should be wound for this work to give about 2,500 revolutions per minute. With a rheostat this speed can then be regulated at will to all cases, from fast to very slow.

When medium length strokes are employed turn on the current with the rheostat all in. Slowly increase the speed till it reaches the rate that does the most active work in the tissues with the greatest sense of comfort and benefit to the patient. Then hold it at that point. By tests on yourself the adjustment of speed becomes intuitive. It is not to be regulated by count, but by effects.

Always begin a new patient with a moderate stroke and a short séance when muscle-work and stimulating effects are indicated. Otherwise the tissues will be somewhat sore next day and will need "breaking in." Begin gently and tolerance will develop in a few séances. If sedative effects are sought reverse the above and begin with a long séance of fine stroke, just as you would with a fine coil-current for sedative effects. Remember that sedation does not tire, while muscle-work may. Once past the breaking in of new and lax tissues there will be no further need of caution and each patient will want "more." Some advocate much slower speed with long strokes than personal experience teaches me are most efficient when carefully managed. The high rate of speed *intensifies* the effects, and some effects can only be obtained by high speeds; but there is one drawback which a beginner must guard against: At high speed the oscillation of the eccentrics tends to throw the handles to a rather troublesome extent and requires the operator to steady one or both of them with his own hands. This is minimized by keeping the patient in correct line with the shaft and sustaining firm pressure on the belt. It is a feature that will no doubt be eliminated by mechanical improvements in the apparatus.

Duration and Frequency of Treatment.—A single sedative application to one region may be five to eight minutes. Applications for circulatory and tonic effects may be about the same length of time, but in practice stop the motor when the desired effects are secured without exact regard to the watch. If only one locality requires treatment the entire application is limited to the time needed to meet the single indication, but if several areas must be treated the same process repeated on each will prolong the séance accordingly.

With all applications that tax muscles by unwonted work make the first séance mild and short. Two minutes will often be enough. Make the next treatment a little longer. The abdomen is the part that mainly requires this caution—when treating constipation and states of atony. After a week of building up full tolerance the most energetic dose and a séance of ten minutes will not tire and will do great work.

For a "general treatment" for constitutional effects without local lesion the main applications are to the trunk and involve several shifts of the belt. The time allowed may be two minutes for each position and a total of about ten minutes will suffice. For local effects on the lower extremities short séances are usually adequate. Three to five minutes may be the average.

When *over*-activity is the object, as in attempting to increase the *combustion* of abdominal fat, the work done in a short séance will be only tonic and not consuming. Push the tissue-work to the needed excess, and a séance of twenty minutes will be required after initial tolerance has been developed. Do not expect to create over-action unless you apply over-action. A tonic dose will not do enough work to reduce obesity, though it will cause the patient to feel more comfortable and to carry his corpulence better. This is not the basic need, however, and a different dose fits the case better.

"Frequency" follows the usual rule with nearly all physical methods of treatment. Daily séances suit acute conditions, and chronic cases are generally treated three times a week. A daily séance for the first few treatments is, however, wise at the beginning of many chronic cases, and the medical judgment of the operator will easily settle this point. Practice with a given apparatus soon enables the physician to know about what it will do, and he prescribes accordingly.

The time at which treatment is given may be important. Local sedative applications can be made at any time of the day, but, when active muscle-work is applied to the trunk of the body, treatment must avoid a full stomach. Allow at least one hour after a very light meal, and not less than two hours after a hearty meal. Vigorous abdominal applications are best made an hour before the next meal is to be taken. Food should not be taken immediately before or just after a treatment that disturbs the conditions of digestion till the circulation regains the normal.

In regulating the dosage for either local or general treatment the factors which make up the totality of treatment must have regard to whether we desire to:

1. Accelerate the general or local circulation.
2. Determine an increased supply of blood to a part.
3. Increase under-nutrition.
4. Excite over-oxidation.
5. Relieve pain, or muscular stiffness.
6. Stimulate internal organs to improved functions.
7. Tone up atonic muscle-fibres.
8. Increase secretion, especially of the liver and digestive apparatus.
9. Increase peristaltic action of the intestinal tract.
10. Secure the effects of fine rapid vibration.

Recognizing the indications for any of these therapeutic effects simply follow familiar medical principles in respect to dose. The relation of resistance of the passive part and the tension of the applicator must be impressed on the mind. With the hand-piece, firm pressure upon the part and support by the opposite hand greatly increases the effect. With the belt it is essential that the patient make firm contact by pushing, pulling, or leaning a portion of his or her weight so that the belt and handles will be under *steady tension strong enough to drive the oscillations far along the tissues*. It is therefore obvious that the base of the machine must be firmly screwed to the office floor. To guard against accidents it should be anchored so securely that a weight of practically the entire body will not upset it. This refers to belt applications chiefly, and in this respect the apparatus is peculiar to itself and technics.

We will next take up detailed directions for each method of clinical application. Not only are these forms of therapeutic apparatus nearly new to the general medical profession, but in this Instruction Course the attempt is made for the first time in any published treatise to prepare practitioners to use them in accordance with the principles of scientific medicine.

Application of Foot-Piece.—This is very simple and has practically but one use: to determine an increased blood-supply to the feet by means of an invigorating exercise. Contact is made to the soles. Shoes need not be taken off unless they are very thick and free action of the parts is impeded by them. Most treatments are given with the shoes on. Sit the patient in the chair with side-arms, facing the machine, and at a distance of about four feet from the base. Hook the foot-piece on the handles as shown in Instruction Plate 294, and carry the belt around the patient's back or around the back of the chair.

Some permit the patient to hold the belt in the hands, but this is often laborious and a fixed support is preferable. Put the feet in position with the legs fully extended so as to exert firm pressure on the soles. As the length of the limbs varies in different persons adjust the belt to the proper distance. With the patient now ready start the current with slow speed of the motor and increase the rate till the best effect is obtained. When the feet are finely warmed, and before fatigue begins, stop the motor and close the sitting. With a stroke of about four millimetres a tonic action on the circulation will be produced. If greater action is desired on the muscles and an extension of the effects up the legs to the knees or above them, increase the stroke to one centimetre.

Application of Hand-Piece.—All other treatments employ both eccentrics and oscillations; the hand-piece is usually employed as a fine, rapid, vibratory treatment with a single eccentric, as two hands cannot well be devoted to applicators at the same time. The free labile movements of other Vibration applicators having flexible handles pertain to a different class of work. The chief uses of this hand-piece will relate to stabile or but slightly labile applications to small local parts to which the fingers and thumb of the operator are dexterously adapted. The action from the machine is then transmitted through the operator's hand to the patient, something as in the old method of labile faradization.

Close one eccentric so that its handle will remain still. Adjust the other to a fine stroke of one, two, or three millimetres as desired for needed effects. Unscrew the lower part of the regular handle and screw on the hand-piece. Run the hand into the two small loops so that the longest clasps the centre of the palm and the other holds the middle finger tightly at the inner phalange. With the patient seated so as to bring the part into exact reach of the operator's pressure with a rigid extension of the handle-bar, make contact with the tips of the thumb and fingers, and start the motor into rapid action. During the séance direct the *pressure* upon the tissues of the region to be treated till sufficient effect has been obtained. This is without any electric-current in the vibrations and concerns mainly the head —nose, ear, forehead, throat, and small local parts needing sedation or delicate nutritional alteration. See Plate 295.

It is well-nigh superfluous to describe the sensory and physical actions of this technic. They can best be felt in a personal test. The applicator can be attached below the spiral spring of the handle

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PLATE 290.—To secure most effective action on either gastric or intestinal regions in a variety of cases with atony, chronic constipation, obesity, or any indication for vigorous local exercise, apply the belt with the patient kneeling on a hassock so as to throw the leaning weight and position of the body on the belt. This gives a superior action on the tissues. Corsets must be removed. The patient's hands steady the belt as seen.

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PLATE 291.—Showing a patient with belt acting on single thigh. Lean part of the body weight on the chair. Turn and shift the direction of pressure on the belt to affect front, side, or back of the thigh. Slip belt to any desired position. With it high up as shown a decided warmth and determination of blood to the genital organs is produced in cases of simple and incipient impotence. Treat both sides. Tonic, derivative, and analgesic effects may be obtained to meet special indications.

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Plate 292.—Application to knee. Rheumatic conditions, chronic synovitis, stiffness, swelling and pain, when rest is not the absolute indication, can be remarkably relieved by this treatment. The sensation during and after the séance is among the most pleasing to the patient afforded by any resource of therapeutics. Regulate the dose as taught in the text. Push back to keep the belt-tension steady.

TISSUE-OSCILLATOR SERIES.

PLATE 293.—To secure tonic, warming, derivative, nutritional, muscular, analgesic, or other possible effects on the lower extremities below the knees, prop the feet against a hassock with enough pressure to give a fixed base for the oscillations of the soft parts under the belt as shown above. One or both ankles, calves, or legs, can be treated in the same manner. Push backward enough to keep the belt taut.

so as to yield an elastic vibration; or, it can be attached above the spring and yield a more rigid action; the patient can operate the hand-piece and guide the fingers by his own sensations, or, the operator can manipulate it as first taught. A short stroke driven at speeds above 2,000 per minute gives the best results. Both the sensory and tetanizing effects on motor points of small muscles remind one strongly of a rapidly interrupted fine coil-current, although there is no electricity in this dosage at all. Make the following series of tests with the applicator secured upon your own hand:

Apply the fingers flat upon the frontal region; do same upon occiput and sides of neck; clasp root of nose between two finger-tips and thumb; manipulate sides of nose and forehead with same; knead cheeks with finger-tips and rapid vibration; with hand maintained in line of axis and patient on revolving stool just touch surface of skin with tips and slowly turn patient so that all parts of the face will successively undergo "facial massage"; with firm pressure by the palm manipulate the entire scalp; slipping down the neck and round to larynx clasp it between tips of fingers and thumb; press index tip on tragus, on the tissues just behind, below, and in front of ear, and in external auditory meatus (Plate 296), and become familiar with all the above actions with strokes of from one to three millimetres, and all speeds from fast to slow. Some of the effects are remarkable and will surprise the practitioner who meets them for the first time. No table of therapeutic indications will be needed after these tests are made, for the clinical work of the technic will be obvious.

Next adjust a little more vigorous stroke and with palm and tips in turn (according to the part) press, knead, or grasp sections of the opposite forearm, arm, ankle, knee-joint, regions over liver, spleen, stomach, intestines, with deep pressure over gall-bladder and such parts of lax abdomens or seats of pain, impaired function, etc., as may require same. Knead the course of the large intestines. Palpate over chest, but not directly over the heart. And with a female patient add to these tests similar ones upon the external parts surrounding the pelvic organs. The practitioner who aims to get out of the hand-piece all the work it will do will find it a very versatile device, although those who have extensive office equipment of other apparatus will naturally turn to what is most convenient for the given case. The great advantage of a variety of apparatus covering related actions and useful in similar cases is not so much the command of different effects as the command of necessary effects with a choice of the most convenient technic in different cases. For some regions the hand-piece of this Oscillator is convenient, while for others it is not. A choice can be made to suit.

Hand-Piece Combined with Electricity.—As conducting cords can be attached to the metallic arms of the Oscillator it is possible to add to its mechanical action the action of any suitable electric-current from a battery placed near the apparatus. In practice this will be chiefly a portable battery of the faradic or galvanic type. Two terminal connections are attached to the standard of the Oscillator. By the usual conducting cords connect one pole of the battery to the standard and the other to a second electrode. The application of the electrodes, regulation of current, etc., then proceeds as if it was an entirely separate matter. The current acts conjointly with the vibration upon the tissues and may be employed or not at the discretion of the operator.

The Belt Applicator.—The belt is the chief and well-nigh universal means of oscillatory treatment, and is the distinctive feature of this apparatus. Belts longer or shorter, wider or narrower, and of many materials may be used, but all should be firm, substantial, and non-elastic. Soft goods absorb waves, and what the patient needs is a belt that will transmit waves with little absorption. Do not wind belts around a part in the hope of improving the result. The true principle is firm contact on one surface with free movements of the tissue fibres in all other directions. The novice overlooks this point and tries many experiments on wrong principles.

With the belt a coarser stroke is used than with the hand-piece. The dose may vary from a medium tonic wave to a strong stroke which works the muscles like a piston-rod. Between these extremes a range of dosage of from eight to twelve millimetres will cover the average of cases. As the physician can best and most quickly learn how to treat patients by first testing the belt on himself, we will now begin a home clinic for instruction which cannot be gained in any other way.

With the eccentrics adjusted to a medium stroke oil the bearings, atttach the belt, throw off the coat and vest and face the machine, standing. Place the belt around the lumbar region and lean back so that the handles are in line with the revolving shaft and tense under a pull of about twenty or more pounds. This tension must be steadily maintained during all treatments with the belt and puts no tax on the patient, as it is merely leaning against a support.

Now start the motor into slow action and gradually increase it till the best working speed is attained. If the handles tend to fly a little shift the line by slightly moving the body to the right or left till the greatest steadiness is secured. With a brief study of this feature a knack can be acquired which will render steady action almost automatic. If necessary, however, lay one palm lightly against the shaking handle on the wooden part and press it enough to temper its oscillations. Meanwhile, never let up on the tension of the belt. Keep it taut all the time.

Having tested this preliminary action let us take up a complete study of the effects and management for the entire body. Put the belt high across the shoulders and adjust the motor to as rapid speed as the length of stroke requires for maximum stimulating work. Maintain this dosage and the tension on the handles by leaning away from the machine and shift one arm out so that the belt is diagonal, under one arm and over the other. (See Plate 286.) Then reverse the slant, and by various positions of each arm test how the muscles of the upper back and shoulders can thus be exercised and circulatory effects secured. Two minutes will suffice.

Next slip the belt down across the dorsal spine by a skilful inclination of the back without relaxing tension or stopping the machine. It is the next step in a general tonic treatment. Now throw the pelvis outward; now the shoulders; advance one foot to give better balance; note the variations of action, and let the belt slip to the belt-line. While doing this use the hands to advantage; feel the waves of widespread oscillation on distant tissues, feel the larynx vibrate; with a palm on the thorax, the abdomen, the thigh, and on all parts within reach, feel what work is transmitted through the soft and shaking masses. With the eyes look down on the effect. He who does not recognize its therapeutic significance can have made no study of therapeutics.

Now gradually make a half-turn sidewise to the right to place the liver and adjacent organs under the contact of the belt. (See Plate 288.) The diffusion of movement that results must surprise the unprepared practitioner, for now the nutritional impulses spread over the entire side, across the abdomen, and take in the liver, gall-bladder, stomach, and large intestines, reach down the pelvis and stir the blood in the genital organs, set the thighs and thorax in a quiver, and if the person speaks the larynx reflects the tremulo. By slight shifts of the trunk let the belt slip lower, and now turn till it crosses the umbilicus. Keeping tight tension pass it down the epigastrium till it stops over the bladder at the pubes. If the stroke is vigorous and the speed rapid the physical work this application means to the tissues needs no description, for words are not felt as the belt is. It speaks for itself.

Test the same action over the spleen and left side and then turn again to face the machine and slip the belt down over the sacrum and gradually cover the outlet of the rectum. (See Plate 289.) Note the astonishing effect; the sense of fulness of the rectum; the contraction of the muscles; the influence on the venous circulation; and the peculiar glow that follows.

After sufficiently testing a few changes of speed and stroke to ascertain what is most effective for different indications stop the motor, bring the revolving stool near enough to the standard to reach with the belt and repeat the above actions sitting down. The revolving seat permits all the necessary turns without difficulty. During the treatment there may be less active effect on the circulation of the lower extremities in the sitting than in the standing posture, but the after-results can hardly differ enough to make the choice other than one of convenience to suit the patient. Let old and feeble persons sit during treatment of the trunk, but prefer the standing position for all who can as easily stand as sit.

Next take in order the hips, acting on each side as for local fat, and over the sciatic for neuralgia; remove one leg from the belt, and with it close to the groin on the other leg test front, side, and posterior positions and effects. (See Plate 291.) Note the possibilities of determining increased blood-supply to the pelvic organs and adjacent parts. Stand during these tests and shift the position of the feet during all the above work so as to add the aid of muscular posturing to the primary oscillations of the force applied.

For the remaining uses of the belt sit in a chair with a back. First test the effect on one knee-joint (Plate 292); then on both at once; then let the belt slip down to the middle of the legs (Plate 293); next to the ankles; and then lift one leg out and note the action on one alone. During these leg tests have the chair far enough from the standard to put the belt on sufficient tension by the weight and pull of the parts to keep the handles taut and steady under rapid oscillations. Also keep them in line with the shaft and as nearly parallel as possible.

At other convenient times repeat some of these tests with the belt over underclothes only, and also in contact with the bare skin. The importance of direct contact or contact through only thin garments is most felt in treatments around the lower part of the trunk. Observe the reddening and warmth of the skin that quickly develops from direct application. In cases of the class commonly called "bilious" the cutaneous irritation will set up itching for a time, but this is merely an indication for a suitable medical adjunct to the treatment till the drawback ceases, and is not a fault of the Oscillator.

TISSUE-OSCILLATOR SERIES.

PLATE 294.—Showing an application with the "Foot Piece." Seat the chair sufficiently back from the standard to have the feet clear it. Use a long belt passing round the back of the patient so as to be self-supporting without effort. Press the soles of the feet against the foot-board and steady the belt at the sides with the hands. Regulate the stroke and speed to suit the indications. The circulatory effects on cold and clammy feet are pleasing. The shoes can be removed if desired, but most cases are treated with the shoes on. The stockings are negligible.

TISSUE-OSCILLATOR SERIES.

PLATE 295.—Showing an application of fine rapid vibration with a single hand-piece held by the operator. The effect and the technic closely resemble the early method of applying a faradic current through the hand of the physician. See text for general directions. The firmer the pressure on the part the deeper the action of the vibrator.

TISSUE-OSCILLATOR SERIES.

PLATE 296.—Showing the patient holding the hand applicator and administering vibration to the ear. Any part of the face within reach can be treated in the same way. It tires the hand somewhat.

Note also that with a coarse stroke and either food or drink recently in the stomach, or accumulation of urine in the bladder, the application of the belt over the part sets up a request to desist till a more proper time. In expert practice all these little details instinctively receive attention without troubling the operator.

Having thus put your tissues to a personal test of the main actions of muscle-oscillation there is still something to learn from comparison with others. It makes little difference about the extremities, but on the trunk of the body the adipose and muscular structure of the patient has much to do with the extent and quality of the oscillating waves. A thin subject has little to transmit the waves; a fatter subject has more. With a thin patient an abdominal or side application of the belt may affect the trunk to the shoulders and the thighs to the knees, but often we may see the cheeks and hair of a stout person share in the quiver and can feel the reflected waves down to the ankles. The very widely distributed action therefore makes the treatment quite different from a merely local massage, and supplies us with a rationale for its use in many cases which would not seem at first to be within its reach.

One more interesting study requires a moment or two before we estimate the value of this device. While setting up vigorous oscillations with the belt on different parts of the trunk of various patients palpate adjacent and distant surfaces with both palms, especially the front and back of the chest, and abdomen and lumbo-sacral regions. It will be a revelation. That a mere machine can exert such evidently valuable therapeutic actions, transforming external force into internal functionation and physiological work, must be unknown as yet to the majority of medical men who have not investigated physical therapeutics. Owing to its simplicity and convenience the apparatus can be used in every office.

Belt Applicator with Electric-Current.—Connect one conducting cord from the selected pole of any desired battery to a pad electrode moistened as usual. Connect a second electrode to the terminal on the standard by another cord, and attach a third cord between the standard and the remaining pole of the battery. Place the pad electrode under the belt and press the other on the opposite surface. Regulate dosage of current as usual before starting the motor. The application must be made on the bare skin. The skilled manipulator of all forms of electric currents with full equipment at command will most often employ their actions independently rather than combine them with mechanico-therapeutics. Both supplement each other superbly, and both are indispensable in nearly all practice beyond febrile and contagious cases and a few specialties.

Important Caution.—It is the rule that patients are delighted with the action of this Oscillator, but one caution is necessary. Do not agitate the stomach and intestines with recent food or drink in them. All other parts of the body may be treated a half hour or so after a meal, but abdominal mechanico-massage must not disturb the stomach when it still needs time for quiet action. Therefore do not blame the apparatus if a patient feels distress when treated at an improper time. To apply rapid muscular movements to the abdomen soon after a person has taken a glass of water or beer, or when food is still in the stomach, or during a "bilious attack," will cause the patient to feel faint, or nauseated, or otherwise distressed, instead of deriving the expected benefit. This is simply a temporary effect *due to treatment at the wrong time in the given case.* Begin all abdominal treatments with caution as to time and dosage, and during the first two or three séances stop too soon to cause fatigue. In this way chance of disappointment will be obviated.

If a patient who has had but one treatment returns with the report that it did not agree with her, that she felt sick after it and was so sore next day that she could not wear her corsets, the physician should realize that all the trouble was due to lack of trained care in the above respect, and should not be likely to occur again. Such a temporary effect must not deter a patient from continuing treatment which is indicated, and, when rightly employed, "feels pleasanter during treatment and leaves a more comfortable feeling after it" than almost any other method in therapeutics.

Portable Device.—Unlike the larger Vibration Instruments designed to be fixtures in the physician's office a small device is made as portable as a medicine case or faradic battery. It is designed to enable the physician or surgeon to *carry his masseur with him* and apply high-efficiency mechanical massage at the home of the patient as well as in office pratice. This is made possible by employing a spring vibrator device instead of a revolving hammer, and by operating it by a small battery of dry cells instead of a street-current motor. It is to the stationary apparatus what the portable galvanic battery is to the large cabinet.

Tests of the endurance of the cells have shown them capable of giving nearly 1,000 treatments averaging eight minutes each, which is about the time allowed for local applications. The applicator is connected to the cells very much as an electrode is connected—by flexible, silk-covered cords, but no current is employed on the tissues. The action is mechanical and reflex. The number of vibrations can be regulated from 500 up to 5,000 strokes per minute, and their striking force varied as desired so as to incorporate in a treatment the kneading, pressing, stroking, rolling, and frictional effects of skilled manual massage, together with a delicacy and power much beyond the hand.

No claim is made, of course, that the apparatus of lesser power will equal the effects of the larger and much more powerful machines. Also, as principles of technic and administration are unchanged no series of Instruction Plates is required to demonstrate the portable dry-cell instrument.

Studies in High-Frequency Currents

(From X-Ray Coils)

"*The application to therapeutic purposes of 'Currents of High-frequency' is chiefly due to the work of such eminent men as d'Arsonval, Oudin, Doumer, and the late Apostoli, and the results obtained are—even in the short time that has elapsed since their introduction—of such importance and promise that it is safe to predict a great future for this new treatment.*"—(Isenthal.)

CHAPTER L

"HIGH-FREQUENCY" MEDICAL ELECTRIC CURRENTS

X-Ray Coils and Static Machines made High-Frequency Apparatus by Step-Up Transformers. Explanations for Beginners. Studies of Electrodes, Actions, and Therapeutics. Results in Tuberculosis. A Simple Alternating-Current Solenoid. A Therapeutic Novelty. Its Physiological Actions. Uses and Technics.

This section of our present study will inform every practitioner who has an X-ray coil that by a small addition to regulate dosage he can make it one of the most valuable therapeutic instruments in his office. Nearly 5,000 of our leading surgeons could to-day be profiting by this fact *if they knew it.* Every one who in future buys a fine X-ray coil can know it and profit by the knowledge if he reads this course of Instruction. The X-ray coil and High-Frequency attachment for therapeutic uses is but the familiar faradic battery grown to full scientific stature and brought up to date by mechanical improvements. To simply point out the fact that it affords the nearest possible substitute for a fine Static machine will indicate to the profession the nature of its medical capacity and scope of usefulness. Let us proceed at once to get acquainted with this practical apparatus.

About a year ago the author received from a prominent physician in London, England, a letter which read in part as follows:

"There will be no need for us to bother any more about Static machines as they will undoubtedly be superseded by the High-Frequency, which will do all that Static will do and a lot more, besides working well in this country in all weathers. The '*effluve,*' or spray, from the terminal of a High-Frequency is very like the Static spray and the sparks are much less painful. For treating the whole body you either insulate on a stool as in static treatment or put the patient into a Solenoid from the windings of which the current reaches the body from all sides. This Solenoid is made up as part of a couch on which the person lies, the hoops being jointed to let the patient in and out. The same couch is designed also for X-ray work. (See Plate 300.)

"Another electrode is a metal tube with an insulated handle which positively exudes painless electricity from its whole surface, and can be applied into vagina or rectum. ——— sells the outfit for £12, and this is worked from an ordinary X-ray coil giving a ten-inch spark. You will have to strike out all you have said about High Frequency in your book on 'Treatment of Disease by Electric Currents.' If you take an ordinary incandescent lamp bulb in your hand and present it to the High-Frequency spray it will glow, and you will feel absolutely no sensation whatever. We are using the High-Frequency here for skin diseases, phthisis, and neurasthenia mainly," etc.

We began to hear of this form of electric-current about 1891-93. For the next three years it was in the stage of investigation. The most scientific electricians in Europe (and a few in this country) made thousands of tests with it, and determined its physical and physiological actions. During 1897-1901 the apparatus rose on the wave of X-ray development, and with more powerful currents at command it fast demonstrated a great and attractive clinical value. Many began to use it, and reports of its results increased in medical literature.

But what is it? Is the High-Frequency apparatus a new *battery?* Is it anything like a faradic battery? or a sinusoidal machine? or a Static machine? Probably most physicians think of it only as some new and strange sort of battery, complete in itself, different in some unknown way from other batteries, but quite impractical and not likely to be useful in their own office. But it is not a *battery* at all, nor is it a mystery. It is not complex and merely experimental and useless. It is simply an intermediate regulator of *a current already derived from a "battery."* It is connected *between* the "battery" and the patient to alter the quality of the dosage. Its simplicity is great, and it need not be expensive. Every one can use it, and its future career is assured.

What is called the High-Frequency apparatus is, in plainer phrase, a *transforming attachment* for large X-ray coils and also Static machine currents as well. It is designed to alter the quality of the secondary-coil current into a more refined current of therapeutic quality and dosage, which, when successfully accomplished, enables the X-ray coil and its expert operator to duplicate many of the therapeutic actions of Static-machine electricity. (See Plates 298 and 299.) When the same device is adapted to the large Static machine some of the effects and uses of High-Frequency apparatus are practically the same as when it is excited by a coil. This simple statement will bring the matter down to the level of ordinary understanding and remove much of the vagueness now in physicians' minds as to the nature of this valuable instrument. References, decolorized, formless, meaningless, from French writings on "*Action des Courantes de Haute Frequence*" have signified as little to American physicians as music to the deaf; but once see the apparatus, see it work, witness its effects, translate its language into practical therapeutics and office practice, and the thing that was ignored before becomes alive with interest and commands immediate admiration.

It is true that the term "High-Frequency" is not a good name for an apparatus. To the ordinary medical man it conveys no idea whatever. It suggests no mechanical picture to the mind; nor does its electrical significance reach automatically out into a profession that has read almost nothing of the terms, signs, and electro-mathematics which are the daily bread of the technical electrician. If the doctor grasps the idea after some explanation that a High-Frequency current is one which is in a state of rapid oscillation during its "flow" it is enough. The rest is dosage and administration. And when the doctor understands from clinical demonstration that dosage and technics are only about as difficult as is the skilled use of scientific faradic currents we may accept the high-frequency phraseology as a matter of habit, just as we do "static currents" in common usage, though the latter term is intrinsically absurd. "Static" is short, simpler than "Franklinic," and easier than "Electrostatic," so we use it apart from its literal meaning. So we do the word *wire*. A wire is a strand of metal, but we *wire* a message as well as a battery, and if you *wire* a surgeon to meet you at the hospital to *wire* a patella there is no confusion about it. Hence our friends of the technical schools may bear with us in our unfortunate electro-medical phraseology. We know it is not scientifically exact, but hair-splitting in parts of speech has to be secondary to clinical results in the work of the average physician.

The great merit and claim to attention of the High-Frequency apparatus is that it doubles the value of an X-ray coil and makes it a therapeutic instrument of the first rank. Every owner of such a coil who bought it thinking that it could only be used for X-ray work can now put it to clinical uses of which he did not dream before. As there are several thousand X-ray coils in this country the importance of extending their uses into the highest fields of therapeutics cannot easily be over-estimated. To plainly picture the apparatus, explain its operation, and teach the American medical profession exactly how to use it in their treatment of patients, will be the purpose of this section on High-Frequency electric-current apparatus.

In following the instruction now to come lay aside all preconceived notions of electro-therapeutics derived from the common faradic battery, and realize that in respect to therapeutic and physiological efficiency the popular "faradization" of tissues is as a pony to a locomotive, compared with the tremendous but refined and harnessed energy of giant X-ray coils and scientific high-frequency transformers. To judge Twentieth Century progress in electricity by the misguiding impressions of an inferior apparatus is an example, set, indeed, by some of our most eminent teachers of medicine, but which rational men who *practice* medicine may wisely leave to others. We can learn more of the truth in a day by personally testing apparatus according to teachings that tell *how to do it* than we can by hearing the greatest surgeon in the universe tell us that "nobody knows anything about it." Distrust "knownothingism" wherever it sticks up its head, either in medicine, politics, or business, and let us rather see what can be learned by following the light of experience and knowledge.

An English author of a very excellent work on Practical Radiography writes the following summary on High-Frequency currents of High Potential:

"Bearing in mind that the High-Frequency Apparatus is only a transformer of electric energy we have to consider the sources of the primary energy. Of the three typical possibilities—the Static machine, the Tesla coil, and the Induction coil—we will here only consider the latter on account of its simplicity and general adoption by the profession. The Induction coil with suitable interrupters and when properly wound, forms at once the most economical and convenient intermediate transformer. Its adoption is furthermore either indicated or desirable because it is the almost universal source of the high electrical voltage necessary to produce X-rays, and there can be no doubt that any medical man who uses X-rays, either for diagnostic or therapeutic purposes, will gladly extend the usefulness of an expensive coil by adopting High-Frequency treatment, while the specialist who makes use of the latter can by the addition of a few instruments add the X-rays to his professional armament.

"For the practitioner who already possesses a coil for radiographic or radio-therapeutic work we may state that (however powerful it may be) it will operate the High-Frequency attachment both safely and satisfactorily, but coils of less then six-inch spark rating are insufficient. The only alteration which may be required is the substitution of some good form of high speed rotary interrupter for the platinum or vibrating mercury break if the coil is fitted with one of these. The High-Frequency obtainable with the D'Arsonval-Oudin instrument rises with the number of interruptions in the current of the coil which feeds the High-Frequency attachment. With certain adaptations of the apparatus various forms of mechanical and electrolytic interrupters can be used.

"The application to therapeutic purposes of 'Currents of High-Frequency' is chiefly due to the work of such eminent men as D'Arsonval, Oudin, Doumer, and the late Apostoli, and the results obtained are—even in the short time which has elapsed since their introduction—of such importance and promise that it is safe to predict a great future for this new treatment. We are often asked what ailments 'High-Frequency Currents' will benefit. It has been proved that they are efficacious in the following cases, but it is equally certain that from the directness of their action upon the cells of the organism an ever-widening field will present itself as soon as their application has become more general: Superficial ulcers, syphilides, psoriasis, eczema, acne, affections of mucous membranes, neurasthenia, neuralgias, insomnia, migraine, hysteria, sciatica, lumbago, rheumatism, rheumatoid arthritis, dyspepsia, constipation, hemorrhoids, pulmonary tuberculosis in early stages, anæmia, chorea, vaginitis, etc.

"The High-Frequency rate of Interruption of these currents, which so radically distinguishes them from ordinary interrupted currents, is produced by the discharge of Leyden jars. To charge the jars we use a coil or Static machine giving a current of high potential connected to the inner coatings. An adjustable spark-gap regulates the dosage of the discharge and the outer coatings are connected either to:

"1. A Solenoid of copper wire, or
"2. To a Metal sheet, or
"3. To the 'Resonator,'

according to the mode of treatment proposed. These are as follows:

"1. Auto-conduction. The outer coatings of the Leyden jars are connected by a solenoid of such circumference that the body of the patient may be conveniently enclosed in it without touching the convolutions of the solenoid. Smaller solenoids for local treatment of arm, leg, or abdomen, may be employed. Currents are thus induced in the tissues of the body. (See Plate 300.)

"2. Auto-condensation. The outer coatings of the jars are connected by a small solenoid, one end of which is in electric connection with a large sheet of metal underneath the mattress of a couch on which the patient reclines while the other end of the solenoid is connected to a metallic handle grasped by the patient. (See Plate 303.) This sets up a general electrification of the entire body. The 'condensation' or accumulation of the current and the action on the patient is nearly equivalent to the accumulation of high potential current on the insulating static platform with machines having sufficient plates in parallel to generate a thick current. (Machines with only eight or ten revolving plates are not large enough to be most effective.)

"3. Bipolar Method. One terminal of the small solenoid is connected to a large 'indifferent' electrode—often a foot bath—while the other terminal is connected to the active electrode, which may be held by the patient or manipulated by the operator as labile faradic electrodes are applied. For local applications with nebulized discharges in vacuo a great variety of low vacuum tubes are employed with a mono-polar connection. This treatment may be considered 'first cousin' to X-ray therapy, the source of electricity being the same but the vacuum of the tube being much lower. The discharge within the tube seems very like the so-called 'cathode stream' of the Crookes tube when a low resistance makes it visible.

"4. Resonator Treatment. The transforming device known as the Resonator is a vertical Solenoid terminating above in a metal pole and ball spark-gap, while the lower terminal of the spiral wire may be connected to one of the windings of the small horizontal Solenoid. (See Plate 302.) Then, according to the position of this connection with respect to the terminal of the solenoid, and the regulation of the spark-gap at the upper terminal, we obtain more or less high voltages at the terminal of the Resonator. The sprays and sparks from electrodes connected with this terminal present the characteristics of static electricity, and may be applied to the body in a similar manner. (See Plate 304.) They are modified in degree by the step-up Solenoid, and with suitable dosage may be deprived of the sharp sting which accompanies the ordinary static spark. Effects can be made similar by technique."

In answer to the question "What are currents of high-frequency?" M. Paul Renaud, of Paris, has written an account from their germ of origin in 1855 to their practical start in 1889 and development since. It is too technical to present to physicians without much electrical education, but after describing other features Renaud passes to certain phenomena of these currents which it will interest us to examine.

"Currents of high-frequency are distinguished from ordinary alternating currents by three essential properties, which are due not only to the rate of high-frequency, but also to the high voltage.

"1. They produce induction phenomena of a very intense kind.

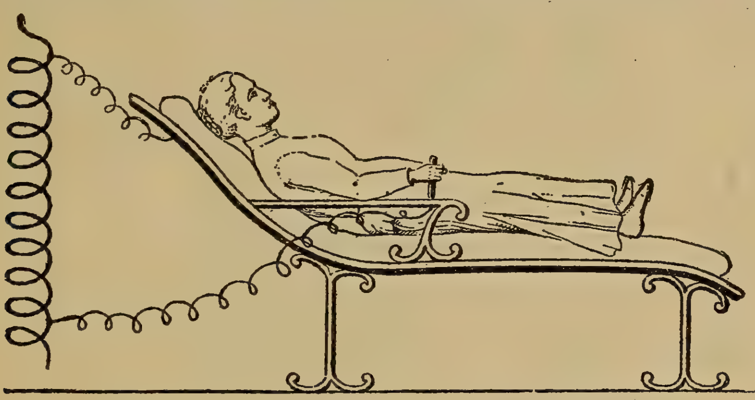
"2. They move on open as well as closed circuit so that contact with a single pole is sufficient to produce current.

"3. They produce remarkable resonance effects.

"Examining these points in detail: the E.M.F. induced in a conductor by a neighboring conductor is proportional to the product of the current by the frequency. One ampere at a frequency of 600,000 will, other things being equal, produce in a spiral the same induced E.M.F. as 100 amperes with a frequency of sixty circulating in 100 turns of wire. Therefore, with a high 'frequency' of oscillation in the current the induced E.M.F. (voltage) in a single turn of wire, whether by self-induction or by mutual induction, is very considerable. Hence in a large solenoid one turn of the wire is sufficient to light, by mutual induction, a lamp of one ampere and eight volts. The beautiful therapeutic method called 'auto-conduction' consists in the application of this principle. Here we utilize currents induced in the circuits formed by the mass of the human body.

"High-Frequency and high potential enables a current to pass on open circuit as soon as the opposite polarities present a certain surface. Thus are explained the uni-polar currents and sparks which occur on touching a single point of the Solenoid. In this case the body of the patient constitutes an insulated surface which, at each oscillation, receives a charge which is almost constant in quantity when the distance from the solenoid is suitably adjusted for the treatment. The corresponding charge of opposite polarity is found upon those parts of the solenoid which are at a different potential at the same moment. This explains the fact that the sparks obtained from a solenoid are greatest at its extremities and smallest at the middle of the turns.

"The lighting of lamps by these currents without contact is explained by condensation effects. The glass plays the part of the



Anti-Condensation Couch for High-Frequency Electrification.

dielectric, the vacuum and the filament forming one of the electrodes and the moist skin the other. From these phenomena two other of d'Arsonval's therapeutic methods are derived: local uni-polar applications which require no special apparatus, and Auto-condensation, the principle of which is shown in the accompanying figure.

"The patient in this case constitutes one pole of a condenser, and thus a mean current of more than 100 milliamperes can easily be made to traverse the human body. Practically all that is said above is familiar in practice to users of large Static machines which easily produce high-voltage effects. To those who use only ordinary coil currents the phenomena will seem new.

"The phenomena of 'resonance' occur whenever a circuit presenting self-induction and capacity has the same 'frequency' as the generating current. This fact results not only in interesting experiments, but in therapeutic applications. Without entering into technical details suffice it to say that the effect of the inducto-resonator is to produce from the coil current nearly the equivalent of the thick positive spray from a large Static machine with a grounded point electrode. By means of the newer coils we can obtain a great range of effects, from very powerful to very slight, by varying the length of spark of the static condenser, and the device itself needs no regulation, the inducing and secondary being always in accord. By placing the movable coil in the middle of the induced we can have two poles or two spray discharges; or we can ground one pole, as is done with the Static machine, by placing the movable coil at one end and either grounding the other or attaching it to the patient by an indifferent electrode. One single large and regular spray is thus obtained for treatment without any disagreeable sparking. The improved bi-polar resonators are of great interest, as they create a zone of greater density of current between the two poles, when it is desired to make a local application. (See Plate 301.) Dr. Oudin reports four cases treated with the recent form, two of them being very rebellious cases of chronic pruritus, and two cases of pulmonary tuberculosis.

"The universal galvanometer is necessary in treatment. It enables us to measure either the volts induced in the secondary circuit, or the mean electro-motive-force of self-induction upon one or many turns of the solenoid, or even the current passing through the patient by uni-polar or bi-polar applications.

"Trials in the laboratory and in actual installations prove that with an installation upon an alternating-current street circuit we obtain:

"With direct bi-polar applications, intensities reaching 500 milliamperes.

"By Auto-condensation on couch, intensities up to one ampere.

"By Auto-conduction method in large Solenoids, a self-induction of twenty-five to thirty volts per turn of wire in the spiral.

"When the Resonator is giving its maximum spray there is an intensity of 300 milliamperes passing between the high-frequency circuit and the resonator.

"The mean current exciting the primary of the new high-tension coils is three to four amperes."

It is a simpler matter to make efficient discharges with alternating current supply than with continuous current coils.

In our section on X-ray therapy, Chapter XXXVIII., will be found reference to the use of a High-Frequency transformer for an alternating-current coil in the treatment of lupus, while we here append part of a report on a High-Frequency transformer used with a Static machine by a leading dermatologist in this country. The High-Frequency attachment employed was made in New York and is already becoming familiar to users of new Static machines who

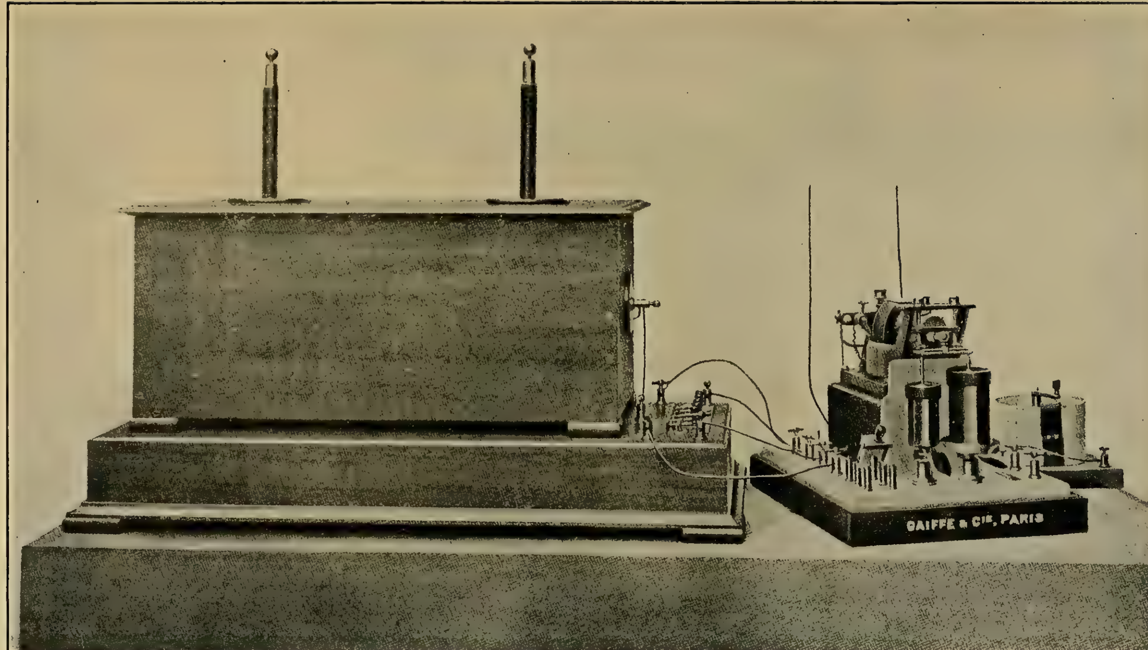


PLATE 298.—This Plate shows a High-Frequency attachment connected with an X-ray coil. It will be seen that the current on its way to the patient starts from the street supply or a cell-battery, and is first transformed to a high voltage and given a type of character by the induction coil. It then passes through the second transformer and becomes what is now called a high-frequency type of current. It is simply the coil current lifted up to a more refined dosage. Fine trituration modifies the action of some drugs, as mercury, for instance, and the refinement of the coarser coil-current lends a modified character to its therapeutic action. This is about the philosophy of H.-F. attachments in scientific electro-therapeutics.

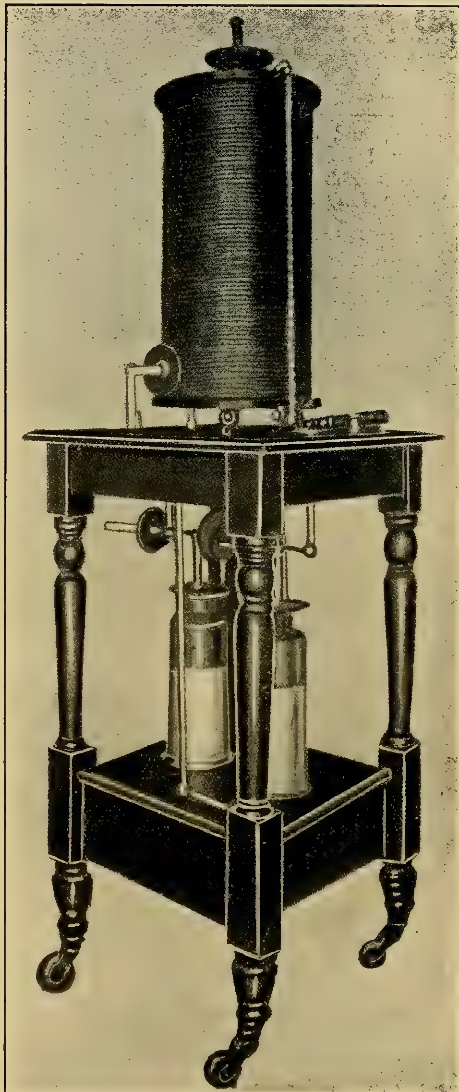


PLATE 299.—This Plate presents another variety of High-Frequency attachment showing the Leyden jars below the table and the solenoid on top, the whole making a neat and practical device on rollers, which can be moved near to the X-ray coil for use and retired when not needed.

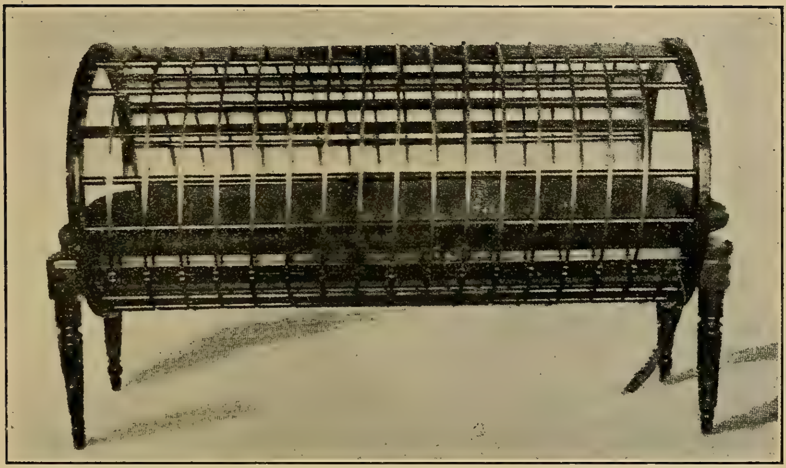


PLATE 300.—Couch with jointed metallic hoops for auto-conduction treatment with high-frequency current, and also for X-ray exposures by folding the hoops back.

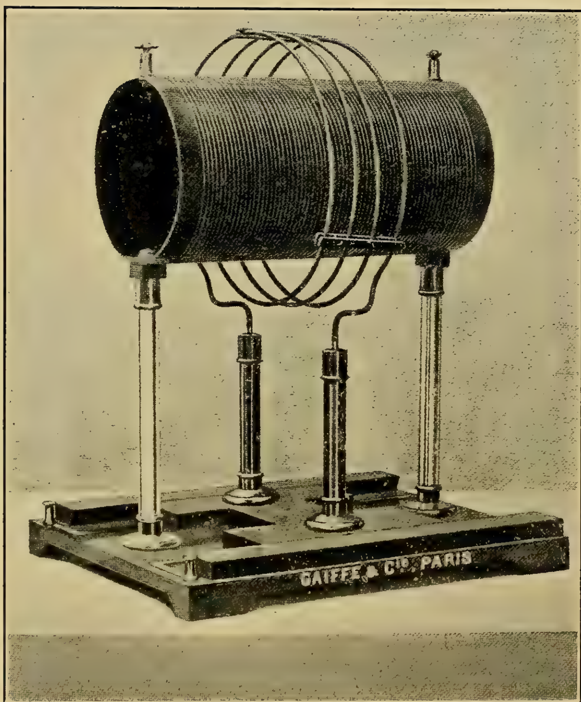


PLATE 301.—Large Bipolar Solenoid of D'Arsonval. An example of large Solenoid for bipolar applications with high-frequency currents. When in use it is connected by a pair of wires to the H.-F. attachment, and the electrodes are connected to the terminals seen in the cut. The application then is similar in manipulation to that of sinusoidal or faradic treatment, the main difference being in the quality of action induced.

procure a full equipment of electrodes and accessories with their apparatus. It has been in the market nearly two years at this writing.

"Static electricity and High-Frequency currents have for some time been successfully employed in the treatment of certain cutaneous affections, more in Europe than in America, and I am enabled by personal experience to corroborate in great measure the claims that have been made in their behalf. The High-Frequency transformer which I attach to my Static machine consists of an inner coarse wire, the terminals of which are connected to the outer coatings of a large Static machine. A long coil of fine wire surrounds this inner coil and the whole is insulated like a Tesla coil. (It is itself a modified Tesla coil of small size.) The outer case measures seven by twelve and a half inches. From one side project the terminals of the primary, and from each end project the terminals of the secondary coil.

"When the Static machine is started into action with a spark-gap of two or three inches between the sliding poles the therapeutic High-Frequency discharge occurs from the terminals of the secondary coil of the attachment. Selected electrodes make this discharge either a spray or a small and gentle spark of very short length. If the dosage is right it is soft on impact and painless and unlike the direct Static sparks from the main machine. If fifty or a hundred of these rippling and non-muscle-contracting sparks are let fall on a single point of the skin the skin becomes slightly reddened, and the blush remains for several hours or even a day or two. On close contact with either or both terminals we feel no sensory effects, but by the interposition of a dry resistance over the tissues the discharge is made irritant to any degree desired. I have used this current so far only with the local electrodes, the point and metallic-lined glass tube. My use has been chiefly in connection with chronic infiltrated eczema, rosacea, acne, localized pruritus, pityriasis capitis, the localized eczema seborrhoicum and seborrhœa oleosum, in all of which resolution of the lesions has been accomplished more rapidly than by any means previously at my command."

In Europe the efforts to improve High-Frequency effects have led to the introduction of coils aiming at higher potentials and the nearer approach to a rich static brush discharge without the addition of a double solenoid. D'Arsonval and several others have designed coils giving bi-polar sprays and an increased range of dosage to the High-Frequency attachment. The entire apparatus of 1902 is an immense improvement over the apparatus of 1896-97.

The first High-Frequency attachment seen by the author in this country was brought here in 1893 to exhibit at the World's Fair in Chicago. It had a low efficiency and was not viewed with enthusiasm by those who tested its action. Not till X-ray coils afterward developed a great field for accessory therapeutics did the High-Frequency attachment receive the attention and improvement it deserved. In America its career is all before it as yet. The author has urged several manufacturers to import a full set of the latest apparatus of this type for the benefit of the profession, but without success. Lately he has been advised that Mr. Howard Jackson, of Boston, is experimenting with apparatus which it is hoped will shortly be available for use. Tests of it made by the author were encouraging, and certainly so simple a matter as a supply of proper devices which are elsewhere abundantly obtainable should not longer deter American practitioners from enjoying the benefits of this valuable therapeutic agent. In this country quite a number are using the vacuum local electrodes, but none so far known to the author have apparatus for the general administrations of d'Arsonval and Oudin. Until the whole technic is employed results cannot be compared. Moreover, it must be noted that a great deal depends on the efficiency of the exciting current and men who employ an apparatus otherwise efficient will fail to equal reported results if they use inferior means to operate the apparatus.

Special Electrodes.—Some of the High-Frequency electrodes resemble those already familiar to users of Static machines and need not be described. There are two newer electrodes which can be used by both High-Frequency and Static currents for local applications, and these we shall here consider. One of them is a section of glass tubing filled with graphite or lined with tin-foil as a conducting material and fixed on the end of a vulcanite handle having a screw-eye for the attachment of the usual conducting cord to the source of current. One maker calls this a "Condenser" electrode, while another calls it an "Induction" electrode. It differs from a Leyden jar in the manner of its discharge, though it resembles in part the principle. The metallic conductor carries the current down within the tube, the glass wall acts as a dielectric, the attracting tissues of the patient on which the outer surface is placed in contact induce a corresponding discharge of spray or spark, and this sets up the therapeutic action desired. The other means of making local applications consists of a great variety of shapes and sizes of low-vacuum bulbs entirely of glass and having a one-pole connection with the source of current by the usual flexible cord. Examples of these electrodes are seen in Instruction Plate No. 305. The author has a number of other shapes and sizes.

The *High-Frequency vacuum electrode* is a low-vacuum tube shaped to suit contact applications to the part treated. The exact degree of low vacuum does not alter the effect except that the higher resistance in a tube requires more current to excite it. A pink discharge indicates a low tube and a blue discharge means a higher tube. The discharge behaves much like the cathode stream when visible in a low X-ray tube. It deflects to the place where the tissues (or any other conductor) touch the glass, and where the stream strikes the glass wall of the electrode it sets up the apple-green phosphorescence associated with X-rays. But owing to the low tension of the bombardment no X-rays are produced, though on close contact the screen of the fluoroscope will slightly illuminate. The action is much like a very low X-ray tube, but in X-ray therapy the Crookes tube is a bipolar vacuum tube of higher resistance.

The single exciting pole may be positive or negative, the other being grounded, and a spark-gap employed to intensify the discharge. The poles exhibit their usual differences of discharge, the positive tending as usual to sharper needle sparks while the negative has the usual character of a softer, warming breeze or spray. The effects resemble those obtained with conducting (metallic) electrodes when a regulated dry resistance is placed between the surface of the tissues and contact of the electrode, and all therapeutic actions and effects of the vacuum electrodes can be duplicated without them, the controlling factor being a regulated *resistance.* In the case of vacuum electrodes the resistance is partly supplied by the glass wall of the tube and the vacuum, and is thus transferred from cloths used by the author with a metal electrode to the similar resistance furnished by the tube from which the current discharges. The principle of action is practically the same, and the therapeutic effects can be made alike.

The excited electrode will glow one, three, or more other vacuum electrodes when held near or against them. When the interrupted current which produces the pink or blue stream in the electrode is subjected to a secondary interruption at rates similar to a slowly interrupted faradic or galvanic current (say seventy-five to 150 times per minute for slow muscular contractions) the effect is the same as that of other slowly interrupted currents employed to contract muscles for exercise.

The rule of " painlessness " follows that (as taught by the author) of all high-potential rapidly interrupted currents and is in accordance with the dosage. This depends on the mass (or lack) of soft parts under the " blows " of the discharge. All discharges can be made painless by keeping the dosage within tolerance, or can be made painful by exceeding the comfortable dosage. Many state that high-frequency currents are without sensation, but obviously this is only true of certain applications of *certain doses* to certain parts of the tissues. The local application of vacuum electrodes follows exactly the same rule of density per area of contact that all other currents follow. Grasp the tube in the palm and it will not be felt with a dosage that is mild for the area of large contact, but reduce the contact to two finger-tips and the strong denser action hurts.

Also, when contact discharges are without sensation owing to the free passage of the current through the slight resistance of the skin, we have only to jump the current through a small air-gap resistance before it reaches the skin to cause sharp needle-sparks to fly, which are intense according to the amperage and voltage of the bombardment and the length of air-gap. Sensation follows the familiar rule of all coil-currents used in therapeutics and diminishes with the lessening of the amperage. The matter is quite fully taught in the author's treatise entitled "Elements of Correct Technique in Electro-therapeutics." No currents are exceptions to these general laws of action.

With the ordinary contact application of a vacuum electrode insulation does not much alter the effect. If the patient is connected with the grounding wire employed with Static machines through a large contact, as, the feet, he will feel no marked increase of the dosage, but if the grounding chain is held in one hand the small contact will intensify the muscular effect on the hand holding the chain. The energy of the discharge through the patient's body is probably increased by the attraction of the closed circuit, but the effect is little seen or felt at the vacuum electrode, at least with the author's apparatus.

Dr. Strong, of Boston, has devised a handle for use with vacuum electrodes which the author received too late to illustrate here as expected. It consists of a hard-rubber handle about sixteen inches long, similar to the insulating handle of the familiar static electrode. At one end is a three-inch piece of open brass tubing running back to a brass disc three inches in diameter with a single row of brass pin-points three-eighths inch long near its rim and facing a duplicate disc with pins situated four inches back on the rubber handle. The handle of the vacuum electrode is fitted to slip in the open tubing just described, which makes a metallic sleeve over the glass and gives a large area of electrical contact.

Just behind the internal disc is a short brass sleeve carrying the ring for connecting the chain or cord used between the electrode and the source of current. This disc is movable on a spring which slides inside the rubber handle. It is worked by a trigger with the thumb and forefinger of the operator's right hand during treatment. Have the patient sit as for a faradic application; have him hold in one hand a metallic electrode connected with the opposite pole of the

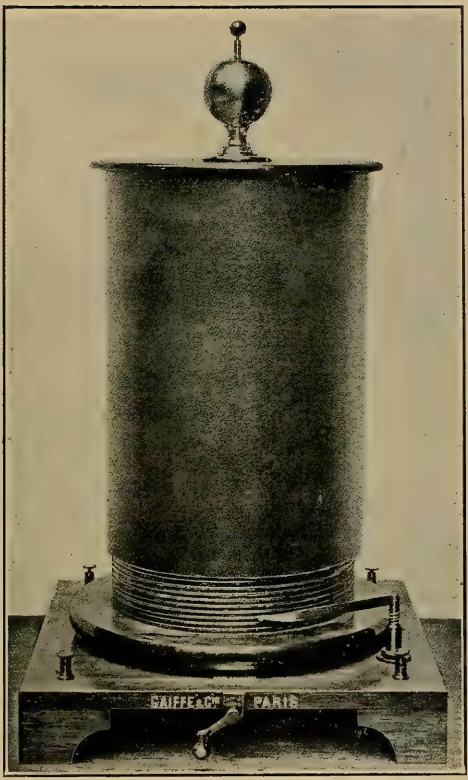
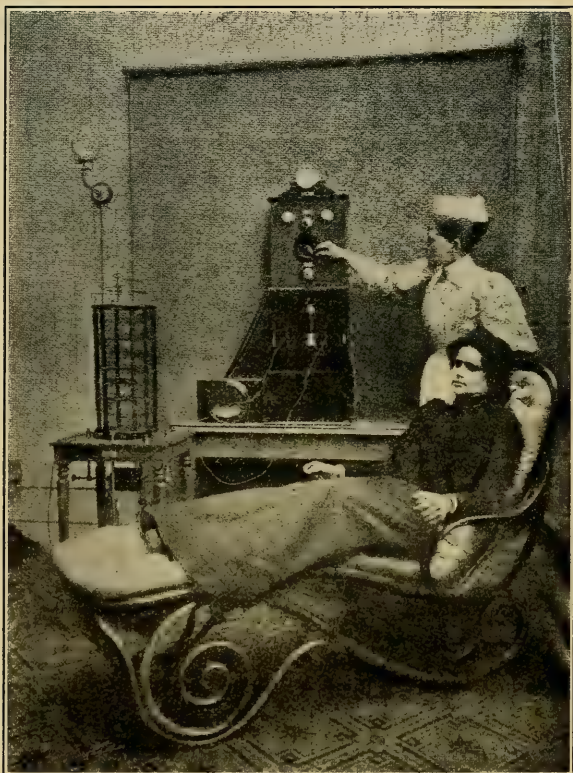


PLATE 302.—This figure illustrates one of the newer models of the "Resonator of Oudin," which is the means of enabling the coil to imitate the static spray for local treatment. It has been varied by different makers and is improved over earlier forms. It is a means of accumulating the current at a high voltage and discharging it in the form of a brush from a pointed electrode.



AUTO-CONDENSATION METHOD.

PLATE 303.—This is the couch on which patients receive an imitation of Static Electrification from a coil current transformed by the H.-F attachment. The position of the patient clasping the handles and resting on the metallic plate which connects with the other pole are shown, as well as the solenoid on the table near, and the nurse cutting out the current at the switch-board.

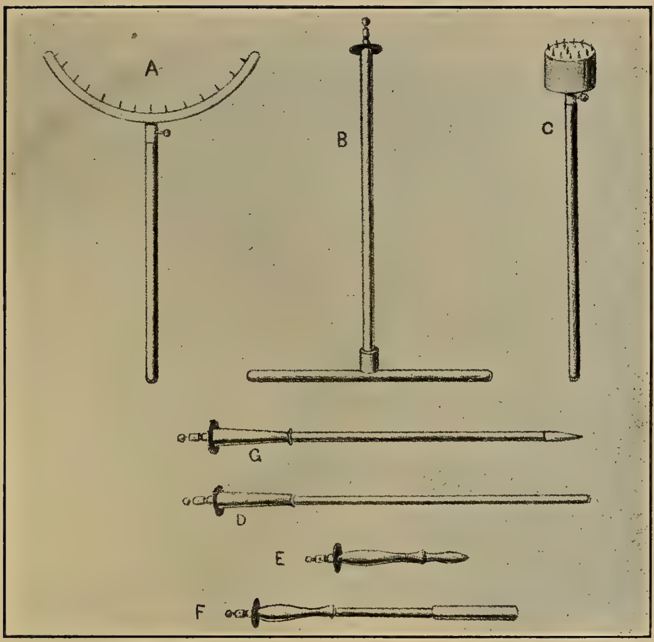


PLATE 304.—Examples of French High-Frequency electrodes. Note the crude resemblance to the author's Static electrodes. By simply understanding that the whole aim of this H.-F. transformer device is to produce with an X-ray coil effects similar to those so readily obtained with efficient Static Machines the mystery of High-Frequency currents is cleared away, and it is seen that everybody who has a large coil can use them to advantage.

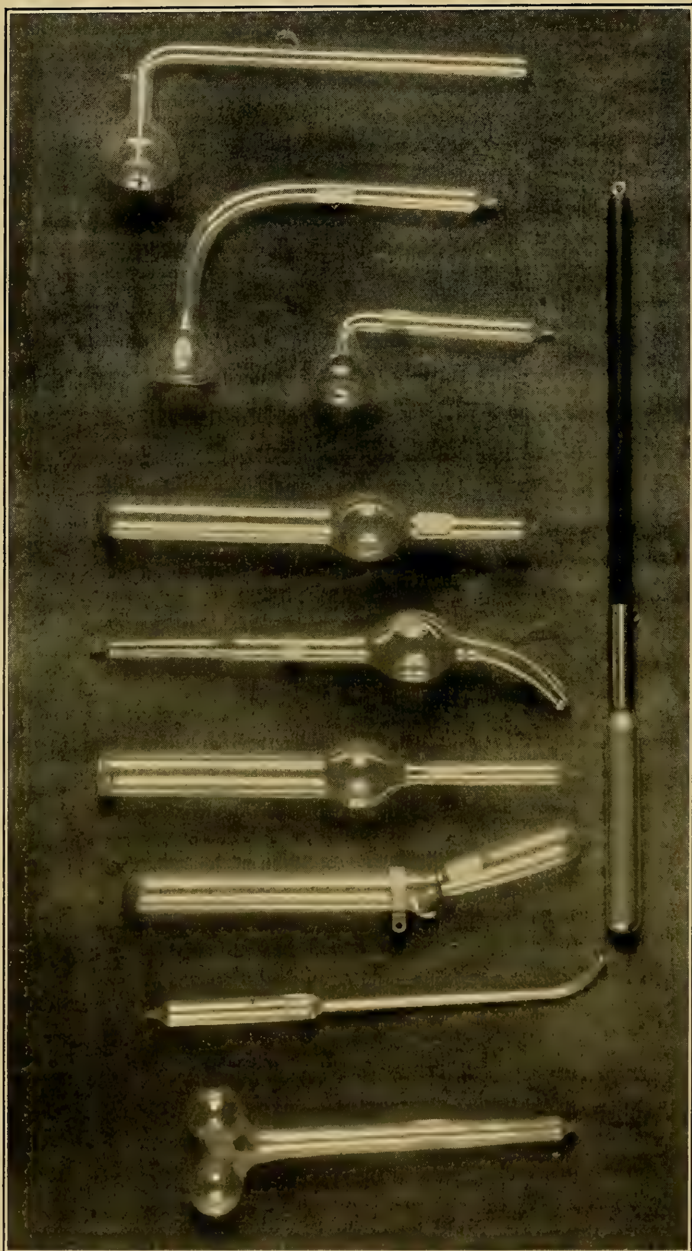


PLATE 305.—A variety of Vacuum-electrodes for use with High-Frequency current. They can be made in all shapes and sizes, to fit any surface or cavity, and adapted to any desired labile or stabile application. The so-called "condenser electrode" with vulcanite handle is shown on the right.

High-Frequency attachment; start the current into action with the discs of this electrode-handle wide apart and by pressure with the thumb slide forward the rear disc till the multiple points nearly meet and complete the circuit of the current and develop the amount of discharge that is required for treatment. The action is self-evident to observation, and a few moments' test will make the method plain. It may be added that these easily made and simple vacuum electrodes are an entirely different matter from Crookes tubes of difficult construction. Some of them are illustrated in Plate 305, but an assortment of fifty will easily be collected by an experienced worker. They are all connected by one metallic terminal to a single pole of the current, and thus differ entirely from the two-pole, high-vacuum tubes for X-rays. They can be made to suit almost any purpose from a rectal, vaginal, urethral, or general electrode to a single or double tube for the eye, or ear. The cost may vary according to size and shape, but simple designs have been only a few cents in price. A dollar has bought any of the medium sizes, and only the large tube to mount as a transformer as described in another paragraph will be expensive. This may cost about $3 or $4.

To our many readers who have large Static machines without as yet obtaining the high-frequency attachment it will be of great interest to procure a variety of vacuum electrodes and use them in the following manner: have a main transformer tube made of straight glass tubing about two inches in diameter and three feet long. Have the vacuum just low enough to create a full rich pink internal stream and mount it like a curtain-pole in convenient relation to the case of your Static machine. Place on it a loose curtain-ring of brass that can slide along its entire length. Put both interrupters on the poles of the Static machine as if for X-ray work and draw the poles wide apart. Ground the positive pole. Connect the negative pole by a flexible cord or chain to the nearest terminal of the large tube, start the current into action and regulate the spark-gaps to excite the tube as desired. Sit the patient on the platform with the surface to be treated exposed as for a faradic application. Connect the selected vacuum electrode with the loop of the curtain-ring by a well-insulated flexible cord just long enough to reach between the ring and the patient without getting in the way.

With the machine at a standstill have the patient take the handle of the electrode and apply the surface of the bulb to the part needing treatment, if within reach of the patient's own hands. If otherwise, the physician holds the electrode himself. Now start the current into action and move the curtain-ring along the main tube till the amount of dosage is regulated to suit. When the ring is nearest the connected terminal the discharge will be densest; as the ring is shifted along the tube toward the opposite terminal the density decreases and the dose lessens. The resulting action is of a warming sedative-tonic-nutritional-alterative nature near the actual contact, but does not yet spread widely through the tissues. To secure diffused effects apply an attracting contact (the hand or a grounded electrode) to the tissues opposite and the current will pass through the parts as it does between two galvanic electrodes. In treatments about the head, in the treatment of pulmonary tuberculosis, and various other conditions this technic of securing deep action is invaluable to the practitioner.

The whole subject opens up a field of Static electro-therapeutics as yet unwritten, for it was not developed when my Manual of Static Electricity was published (1897), and it has so far been the only text-book devoted to this important apparatus. But if time permits the present author to again take up the work and re-write the now enormously enlarged therapeutics of Static electricity there will be many surprises for readers who infer that sparks, the breeze, and old routines are all the story. The author's system of using direct Static currents by spark-gap interruptions* (described by me in 1893) has lately become remarkably popular and awaits fuller description from my pen. Under the substitute name of "wave currents" my methods have been enthusiastically taught and highly praised by several others during recent years. In the present volume we can only make brief mention of the fact and must limit our teachings to high-frequency attachments of the coil.

With a series of these electrodes the student can make various tests of action and effect upon himself, and in a couple of hours learn to regulate the dosage and manipulate the selected instrument. Begin with the electrode in contact and vary the current. Then vary the situation of the electrode on the surface of the part. Then test the effect of lifting it from close contact and observe the air-gap required to develop all degrees of stimulation and finally irritation, as mild or intense as may be desired. See how nearly the sharp fine needle-sparks resemble those of the Static machine when the electrode is lifted just beyond the limit of convection and the air-resistance forces a commencing disruptive discharge. While new to the coil-student all these tests and actions are familiar to readers of our other works. At

* A description of this method was first published in the *Times and Register*, September 9, 1893, under the title of "A New Static Interrupted Current; a New System of Therapeutic Administration of Static Electricity Based upon the Principle of Potential Alternation." It covers all known methods of employing the direct Static current with spark-gap interruptions, in contrast with the Leyden jar currents.

this point we may note the presence of ozone in large quantities in these sprays, and also the following item regarding their richness in ultra-violet rays of great therapeutic energy. The author long ago pointed out the fact that spray discharges from high-potential sources of current, such as the Static machine and the Oudin Resonator, must be rich in ultra-violet rays and possess a similar action. Dr. H. Strebel makes the following statement (1901), which is instructive:

"Kindly assisted by Dr. H. Ghent, Professor of Physics at the Munich Polytechnic, I have succeeded in proving that the invisible rays of a powerful spark-coil are capable, even through a dense medium of quartz, of completely destroying at some distance and within a short time, say twenty minutes, strong growths of bacilli, as, for instance, Micrococcus prodigiosus. The inductive spark being in itself very rich in ultra-violet rays, the proportion of these may be enormously increased by employing certain substances as electrodes, and by making use of a Leyden jar as the regulator and accumulator of electricity. For myself I utilized electrodes of aluminium and cadmium, with the result that the invisible part of the spectrum, rendered apparent to the eye by a projection on a barium platino-cyanide screen, overlapped its visible part by more than four times its length. My experiments with Finsen's lens-filter have shown that, after the passage of the luminous rays through the system, the real ultra-violet rays had been completely absorbed in the apparatus, and further that the chemical-bactericidal action of the apparatus is due to the chemical-bactericidal force of blue-violet in particular. Inasmuch as the latter are comparatively weaker in their chemical action than the invisible ultra-violet rays, the success of my experiments points very clearly to an improvement of the photo-therapeutic method, to wit, the increased bactericidal influence of the light, the simplification, and, above all, the cheapening of the process. For whereas the Finsen apparatus requires eighty amperes, considerably weaker currents are necessary for the working of the induction spark. Any one provided with a radiographic installation is able to verify my results at a small expense, and, finding them conclusive, to undertake treatment by light. I am at present engaged in testing the permeability of various media by ultra-violet rays, and the action thereof on sundry bacilli. In addition I am examining whether the Becquerel rays, those of uranium and cadmium, which, like the Roentgen rays, act through media impervious to light, do not lend themselves to bactericidal purposes. This might be of considerable therapeutic value in many skin diseases."

Studies in High-Frequency Therapeutic Actions.—Passing now to the practical use and clinical results of High-Frequency currents we find a number of scientific investigators on record as to the nature and value of this agent. The uninformed critic who has never studied any form of electro-therapeutics beyond the toy crudities of "faradism" or a red acid galvanic battery without meter, interrupter, or accessories, is prone to assume a lofty and oracular "scepticism" on the subject of High-Frequency currents and pretend that "a great deal is not known about them." But to the many who have devoted hundreds of hours to research and investigations in all branches of scientific electro-therapeutics these currents of High Frequency and High Voltage seem but old and faithful friends in a new guise which only alters their actions and enhances their sterling worth.

Oudin's report to the International Congress, Section of Electro-therapeutics and X-rays, Paris, 1900, has been summarized as follows:

"The effects of High-Frequency currents can be divided into the following actions:

"1. On motor and sensory serves.

"2. On the circulation.

"3. On oxidation generally.

"4. On micro-organisms.

"The effect on motor and sensory nerves varies according to the technique and amplitude of the oscillations of current. D'Arsonval in his experiments used a frequency so high that neither motor nor sensory nerves were excited, but with lower frequencies and with the continuous generation of the current interrupted, the nerves will be excited as with other interrupted currents. The action upon circulation has been observed by many authors. A lowering of blood-pressure at the time of application, and also an intense vascularization of the skin are observed. These currents can therefore cause a most active draining of the circulation. The action of high-frequency currents on oxidation in the organism is an effect fully established by the works of d'Arsonval. An increase in respiratory exchanges and in the quantity of the excreta is observed. These facts have been confirmed by a great number of writers, but they have recently been controverted by others. This difference of opinion must be attributed to a difference in the instruments used in the experiments, and will be cleared away by further work.

"We owe to d'Arsonval and Charrin most of our knowledge of the action of high-frequency currents on microbes and toxines. If the increase of temperature be eliminated they have but a weak action on the vitality of the microbe, but some of them can be attenuated and probably further research by improved methods will disclose more."

Doumer supplemented Oudin's remarks as follows:

"The therapeutical effects of high-frequency currents of high tension are much more distinct and precise than their physiological effects. In diabetes, gout, rheumatoid arthritis, Bright's disease, etc., their effects are no more efficacious than those of static electricity (by Monell's methods). As early as 1893 static electricity was applied to local affections of the skin, either as a spray or sparks, and cured certain skin diseases, both moist and dry, with surprising rapidity.*

"This treatment of skin diseases by static electricity has become a classic method, and it is observed not only that the area treated is cured, but a deep and general result follows which extends to the whole organism. The High-Frequency currents obtained with the Oudin Resonator seem to be more efficacious than static currents as we have applied them. As early as 1897 we applied High-Frequency currents to the treatment of anal fissure with results so good that a cure was the rule, and benefit was often obtained on the first application. The congestive phenomena in the pelvis which so often accompany fissure are removed by High-Frequency currents. As the author announced in a former paper, hæmorrhoids are, in the majority of cases, susceptible of cure by this current.

"These currents are not less useful in the female. They quiet local pain, cause the absorption of the products of former inflammation, and if they do not immediately cure metritis they at least relieve it even when it is gonorrhœal. In a word, all inflammatory states justify this form of application.

"Their curative action on chronic pulmonary tuberculosis is one of the most recent demonstrations of these currents. We have arrived at the conclusion that by the application of high-frequency currents the general condition is improved, the bacilli diminish, the anorexia and fever decrease, and the pulmonary lesions cicatrize, even to a complete cure in many cases. The results obtained are constant. Most of the therapeutical properties of these currents by their general methods of application are due to the increase of tissue resistance which they help to establish. Nature does the rest."

In a note on the action of High-Frequency currents upon elementary respiration and the activity of exchanges between the blood and the tissues (June, 1900), M. Tripet studied the effects of High-Frequency currents in reducing the oxyhæmoglobin. An abstract is as follows:

"MM. Apostoli and Berlioz have proved that under the influence of High-Frequency currents the production of urea is increased and brought near the normal amount, viz.: twenty-seven to thirty grams in twenty-four hours, in cases where defective nutrition showed itself by a marked 'hypo-azoturia.' Cases were watched for two years, before, during, and after treatment. The examinations of the blood were carried out by means of the hæmato-spectroscope of Henocq, the activity of the reduction of hæmoglobin being ascertained by his procedure of elastic ligature of the thumb and the results were marked on special charts. The examinations were made every four weeks from the beginning to the end of treatment. Some of the cases were

* "Static Electricity in Cutaneous Affections" by S. H. Monell, M.D., *Medical Record*, November 18th, 1893.

thus followed during more than six months. The results of treatment may be summed up as follows:

"1. In thirty-seven cases High-Frequency currents (as applied) enhanced the reduction of oxyhæmoglobin, and this was especially apparent in cases of impaired nutrition—rheumatism, fibroid tumors, etc.

"2. In six cases the treatment reduced an existing hyper-activity to normal.

"3. In six cases the activity of the morbid processes was unchecked.

"From these observations it is concluded that:

"(*a*) In case of the failure or perversion of nutrition treatment by High-Frequency currents has the effect of regulating the activity of the reduction of oxyhæmoglobin.

"(*b*) When the activity is below normal treatment increases this activity and maintains it at or near the normal standard.

"(*c*) When this activity is exaggerated—for example, in diabetes—treatment diminishes the activity and brings it down to normal."

A private resumé of the subject by a Boston physician (Dr. Strong) concludes as follows:

"I have been engaged during the past five years in studying the therapeutic action of currents of High-Frequency and High-Potential.

"One of the most striking effects of the High-Frequency current is its action on the Sympathetic Nervous System. Applications of the vacuum electrode over the solar plexus will almost immediately relieve, and later, permanently cure, cases of long-standing nervous dyspepsia, hepatic torpor, constipation, renal insufficiency, and, finally, all conditions due to lack of vasomotor stimulation. I have seen patients whose feet and hands had been cold and numb for months at a time, react immediately to application of the vacuum electrode over the epigastrium. The flesh below the nails becomes pink, sensation returns, and the patient goes away feeling a glow all over the body. The immense glandular stimulation of these currents is seen from the fact that after holding a metallic electrode for a few minutes the hand will be found to be bathed in perspiration. As a result of the vasomotor stimulation produced by these currents, all local congestions are promptly alleviated; particularly congestive headaches.

"I feel convinced that High-Frequency currents are destined to play an important part in the therapeutics of the future, more so, indeed, than any other form of electricity known at present. They seem to be the nearest approach to artificial nervous energy that we have as yet been able to produce."

From a paper on the High-Frequency current by an American physician whose experience with this apparatus was restricted in technics to far less than the full scope of English, French, and German methods and appliances, we take the following published in December, 1901:

"I have succeeded in producing a healthy base in a very unhealthy ulcer by the discharges of the local foil-lined glass electrode. I have also succeeded in curing one very obstinate case of neuralgia which involved nearly every one of the intercostal spaces and centred with great severity and persistency over the solar plexus. This case had resisted all forms of treatment, both medical and electrical. The Static breeze afforded slight amelioration, but it was only slight. The High-Frequency current was applied with the foil-lined glass electrode over the back, over the nerve-roots, over the entire chest, and especially centred over the solar plexus. It required only nine treatments at the rate of three per week to entirely relieve this patient.

"There has been an apparent success with this current in my hands in a form of disease in which I little expected it, and that was a very chronic case of rheumatic deformans. The patient had suffered with more or less arthritic pains, accompanied by deposits in every joint, for the last fifteen or twenty years. He had finally reached the point that he was no longer able to work, and last of all his hands became about twice the size that they were normally. Every joint, carpal and metacarpal, was involved. He was unable to close them sufficiently to hold anything in them, or even to button his clothing. He was a dreadful specimen of this terrible disease. I began treating the hands simply with the high-frequency current, using the glass-lined electrode, and giving sparks about one-half or three-quarters of an inch in length. The hands were showered with these sparks for fifteen or twenty minutes, three or four times a week. They were the last to be affected, and consequently, I reasoned, would be the first to show signs of improvement, and therefore I selected them for treatment. However, they had been in a useless state for five months when treatment was begun. To my surprise they decreased in size so rapidly that I began to feel the deposits in them were not of the same character as were in the rest of the body. They became more limber; he was able to button his clothing, finally able to close his hands. I then concentrated the treatment upon a knee-joint which had been enlarged for more than two years and which was accompanied by some contraction of the hamstring muscles. I found, also, that this joint decreased, and that the pain and soreness and stiffness decreased in proportion to the decrease in the size of the joint. This is the only case of rheumatic deformans in which I have given the high-frequency current a fair trial, but I propose to continue investigation in this line. Just why it should relieve such a condition I do not pretend to say; in fact, was surprised at the result. One thing is noticeable here, and that is the action seemed to be purely local, results being obtained only on the parts that were treated.

"When we consider the enormous rate of vibrations which take place with these discharges, we cannot tell what may be the result upon the nutrition, upon those forms of deposits which have a lower rate of vitality than the normal tissues have, such as these deposits certainly do have; and, last of all, what results it may have upon the circulation and circulating fluids.

"Doumer and others have treated numerous cases of fissure of anus with uniform success as follows: The electrode is carefully introduced sufficiently deep to include the whole of the sphincter muscles. The violet sparks are then applied for from five to eight minutes. He claims that improvement is usually rapid; the pain gradually diminishes, the fissures become cicatrized, and spasms yield readily. He also claims that he has treated gonorrhœa very successfully. His method is to carry the current to the part by inserting an instrument into the canal, or a glass-tube electrode located on the perineum. Excitation at once diminishes, nocturnal troubles disappear, œdema decreases, and while the discharge keeps up sometimes he has seen a cure in ten or twelve days. He claims that in epididymitis and prostatitis the results are marvellous. They yield to a single application, improve at the end of three or four minutes, and next day there is no pain at all. Oudin has reported numerous cases of eczema and psoriasis cured in a remarkably short time by high-frequency discharges. I would say that it is generally admitted by all who have used this form of electrical manifestation that it has a great future before it in the treatment of heretofore incurable skin diseases.

"I might go on citing hundreds of cases cured by this form of electrical manifestation, for, while it is yet new to the field of electro-therapeutics, its popularity is so great with all who have used it that hundred of cases are already on record, but time will not permit."

The following is taken from the report of a local surgeon on his experience with High-Frequency currents in a limited form of treatment with vacuum electrodes only:

"The current is conveyed to the patient through a vacuum glass electrode and is devoid of sensory disturbance other than a sensation of warmth. The effect of the treatment on the blood is shown in an increase in the number of red blood-corpuscles and in the percentage of hæmoglobin, together with a diminution in the number of white blood-corpuscles. As a rule in chronic cases where daily applications are given an ordinarily good result will be manifest in a month.

"The author reported 250 cases and concluded that the method was of value in both acute and chronic conditions. He had observed the benefit from its use in tuberculosis, syphilis, carcinoma, locomotor ataxia, neuritis, torticollis, paresis, nerve exhaustion, impotence, diabetes mellitus, Bright's disease, septicæmia, oophoritis, dysmenorrhœa, anæmia, and leukæmia. A considerable number of cases of pulmonary tuberculosis associated with fever and bacteriological evidence of mixed infection had been treated. In these cases two treatments were given daily, and in each instance the sputa had become more liquid, the night sweats had diminished, and food which had previously been rejected was retained. In a week or two there was an improvement in pulse and respiration, with free expectoration of shreds of tissue and a very large number of bacilli. The cases were advanced ones and were treated only to observe the effect, but not with any expectation of cure. The action on the bacilli was demonstrated by daily examinations.

"In external suppurative inflammation results were secured which in two or three instances were little short of the marvellous. The benefit was especially noticeable in cases of mastoiditis where operative measures were apparently indicated.

"In ten cases of diabetes mellitus the results were gratifying. The quantity of sugar averaged in these cases from one and one-half to four and one-half per cent. Brilliant results had been obtained in both acute and chronic alcoholism. In cancer the general health had been markedly improved, with diminution of the pain, odor, and discharge. Twenty-five cases of muscular rheumatism were treated with complete success. In rheumatoid arthritis the results were equally good though obtained more slowly." (November, 1901.)

Dr. Riviere's experience with Resonator sprays and localized High-Frequency applications on malignant tumors was as follows: *

"Case 1.—A medical man with epithelioma of face came under my care in April, 1899. He was averse to surgery and desired to test High-Frequency currents, with which he was familiar. Trusting to the modifying power of the Resonator spray upon phagædenic and infected wounds I began treatment at once. The lesion had first shown itself as a small wart on the left cheek which subsequently disappeared. Some time afterward there was a brown incrustation on the same place, which the patient kept removing. The crusts had been succeeded by an excoriated surface which was two centimetres in diameter at the time I first saw the case. It involved the entire thickness of the skin as well as a certain amount of subcutaneous cellular tissue.

"It was covered by deep yellow incrustation. Its margin was perpendicular and indurated, the surrounding tissue being infiltrated and vascular. The glands were not much involved. The patient was aged sixty-two; two of his ancestors had died of cancer. His general condition was fairly good.

"I applied at the first sitting short thick sparks and sprays, produced by a coil giving a twenty-five centimetre spark, and the small resonator (first model of Gaiffe). The exciter consisted of a small sponge moistened with Van Swieten's fluid, and carried on the end of an insulating handle. The sparks caused a good deal of pain at

* Journal of Physical Therapeutics.

first, but were better borne toward the end of the sitting, which lasted one minute. The patient experienced great relief at the time he left me, and told me the next day that he had suffered much less from the ulcer during the first few hours that followed the treatment. The serous discharge was more abundant, the crusts had fallen off leaving a smooth red surface. The indurated margin was less apparent. The swelling of neighboring tissues was much diminished. Like all patients after high-frequency treatment he had slept better and felt stronger.

"I made another application; and to render it less painful I used an electrode made of a glass handle, the interior of which was traversed by a metal stem (condenser electrode). The end of the tube, cleansed in the first instance by Van Swieten's fluid, was applied to the base of the ulcer before putting the apparatus into action. The very small sparks which passed between the metal and the glass inclosing it produced no pain, and I made an application lasting three minutes. Under the influence of the current the ulcer became blanched, but after a little time regained its red appearance. Next day the patient felt relatively well, the pain and feeling of tension of the ulcer and neighboring tissues were diminished, the serous discharge had become very abundant, and an eschar had appeared instead of the incrustation. I advised a rest for three days, and I then resumed daily treatment of one minute duration.

"At the end of ten days the eschar had separated, leaving a healthy granulating surface, but the size of the ulcer had increased. The surrounding tissues were no longer infiltrated, the indurated margin had disappeared and the ulcer presented the appearance of an ordinary healing sore. I continued a one-minute application every three days; as new crusts formed from time to time, it was necessary to remove them, and this delayed the healing. After a month's treatment the ulcer affected only a small portion of the skin and did not measure more than one centimetre in diameter. The patient was obliged to leave for Belgium. There he heard of a doctor who cured cancer by means of a special process. He underwent this new treatment and got well in eight days. Two months afterward the affection reappeared, and got rapidly worse in spite of the treatment in Belgium. Death resulted recently, after the patient had undergone two operations.

"On comparing this case with those which I am about to relate, I feel inclined to attribute the first disappearance of the affection to the electrical treatment. The failure of the second method of treatment, which is evident by the relapse which occurred, seems to prove that such treatment was of no avail when acting alone.

"*Second Case.*—The patient was a man of sixty-five, brought to me by a *confrère.* He suffered from a small cancroid about the size of a pea, like a wart, with indurated edges, upon the ala of the nose. I simply touched the tumor for one minute with a small steel rod attached to the Oudin resonator, and carried upon an insulating handle (the spark of the coil being thirty centimetres). The point touched became blanched and then resumed its normal color. Next day the small growth presented a brown color. I repeated the applications of one minute duration upon four days in succession. Twelve days afterward the small desiccated tumor fell off, leaving no trace behind it.

"*Third Case.*—The patient was the wife of a medical man, and I had attended her for a month without any apparent result, excepting perhaps an improvement in her general condition. She had undergone an operation two years before for an adeno-sarcoma of the left breast. All the glands of the thorax and neck were involved; radiography had shown that the lungs were infiltrated at certain points. Daily applications of effluves from the large Oudin resonator, employed simultaneously with injections of cacodylate of soda, had not apparently produced any change in the local condition. It is necessary here to note the difference in the result; this seemed to bear a relationship with the difference in the nature of the affection, this adeno-sarcoma being of a very different nature anatomically, and doubtless etiologically, from the above-named epithelial tumors.

"*Fourth Case.*—I have also had under my care two epitheliomas of the uterus, not admitting of surgical operation. The first was treated by means of platinum needles thrust into the growth and attached to the end of the small solenoid. In the second a *tampon* impregnated with salol or Van Swieten's fluid was applied upon the tumor, the tampon having previously been attached to the resonator. The result was the same in both cases; abundant sero-sanguinolent discharge during and after the operation. After a few sittings the fungating growths fell off as a dead tissue, the sores seemed to be improving, when the patients, who hitherto had shown no appreciable results, suddenly ceased to attend. The pains had not diminished, and the sanguinolent discharge had increased, but the *malodeur* had improved.

"*Fifth Case.*—A female patient, operated on for carcinoma of the breast a year ago, noticed that the infiltrated and swollen edges of the cicatrix took on a normal color, and the appearance of healthy tissue after forty localized high-frequency applications carried out every second day, by means of a large moist roller electrode. When I commenced the treatment a relapse had seemed exceedingly probable.

"*Sixth Case.*—A patient sent to me by a *confrère*. Has been under my care for four months. On arrival she presented a sarcoma (which had returned after operation) as thick as the wrist, in the utero-rectal region. She was unable to defecate without mechanical procedures. Under the influence of daily treatment, lasting a quarter of an hour, the tumor diminished more than two-thirds. The stools are regular and her general condition is considerably improved. She says that she feels fifteen years younger. In this case I used a glass cone filled with metallic filings attached to the Oudin resonator.

"It would appear from the foregoing that high-frequency currents cure small epitheliomas of the face, and in certain cases influence for the better the evolution of malignant tumors. They produce in the first instance a thermo-electro-chemical action, which has the effect of eliminating the neoplastic tissues and admitting the parasitic theory, of destroying the micro-organisms and their tissues. In the second place their action is tropho-neurotic and curative, restoring the vital processes to their normal condition. There is no question of employing this thermo-electro-chemical action for the purpose of dealing with large tumors; for such—complete ablation remains the only treatment; but even in these cases the procedures above indicated ought to be employed with a view of preventing the return of the disease. High-frequency currents, and especially the effluve of the Oudin resonator, seem to produce the effect just mentioned by modifying the vitality of the new regions contaminated by the operative lesion. This special application of electricity certainly appears to be at the present moment one of the few therapeutic measures available in the case of tumors that do not permit of operation."

High-Frequency Methods and Consumption.—It is a remarkable fact that while International Congresses on Tuberculosis and enthusiastic specialists in Phthisis-Therapy probe theories as deep as wells and sweep the skies with scientific telescopes in search of some toxin for bacilli they yet leave the patient in practice to nature's "open air," and medication a generation old without advance, and all the time the rational and most valuable remedy known is treated by the majority as if it was an enemy to those who so sorely need it. Nine-tenths of the politico-medical agitation about tuberculosis would be obsolete if the agitators accepted the aid of high-efficiency electric-currents and skilled methods of treatment in combating the disease. Having for some years demonstrated in practice results equal to any that are claimed in the following pages I herewith submit reports as to the benefits of High-Frequency methods, with the remark that nothing in medicine is more certain than that as good or better results can be at the command of the entire profession if desired, and can be bestowed on 100,000 patients as certainly as on 100.

Dr. Chisholm Williams read a short paper before the Tuberculosis Congress in London, July, 1901, on "The Treatment of Pulmonary Tuberculosis by means of Electrical Currents of High-Frequency and High-Potential," in which he followed the clinical methods now well known and formulated by Professor Doumer, Drs. Oudin, Riviere, and others. His closing remarks state in brief:

"The coil used gives a current of High-Frequency, large quantity, and high voltage. The secondary terminals of the coil are connected to the inner coatings of two Leyden jars. The outer coatings of the jars are connected with the Solenoid from which the High-Frequency

PLATE 307.—Set of Alternating Current Solenoids showing sizes for different parts of patient. For use simply screw plug in lamp socket.

PLATE 308.—Three applications of Alternating Current Solenoid. The central figure shows the body tube slipped up the trunk after the patient has stepped into it and the man is now ready to sit comfortably for treatment as is shown by the next figure on the right. At the left is seen an application of a tube over the head for the relief of pains, etc. No clothing is removed and the only sensation is the mild heat. If this gradually becomes too warm during a long séance simply change to a cold tube or wrap a large towel around the part. The body treatment as seen in this plate has been efficient in many general diseases, and in pulmonary tuberculosis is one of the best nutritional tonics. The pelvic circulation is equalized and pains of neuralgic and congestive dysmenorrhœa are relieved.

SOLENOID.—As many physicians and surgeons have no idea of what a solenoid is or what its purpose, we will here cite the definition of a leading dictionary: "Pipe-shaped; a channel; a spiral of copper or other conducting wire wound in the form of an open cylinder so as to be nearly equivalent to a number of equal and parallel circular circuits arranged upon a common axis. The ends of the wire are brought to the middle point," and when a current is passed through the circuit the solenoid behaves partly like a magnet and partly like an induction coil. When a body is placed within the cylinder of the spiral through which a current is passing the action depends on the quality, character, and amount of current, and on the relation of the windings to the current but when constructed for medical work the body in the solenoid is acted on by induced-magnetic lines of force, which have nearly the effects of general static electrification when the patient simply sits on an insulated platform connected with one pole of the Static machine. It is essentially a general tonic nutritional influence upon the physiological processes of the system. The use of the solenoid is but one of four chief ways of treating patients with what is called High-Frequency electricity. To possess therapeutic energy the exciting current must have the requisite qualities, and other degrees of current would be inefficient. This explanation should make the matter plain to the average reader.

PLATE 309.—A delightful séance for gouty or rheumatic feet. Simply place the feet in the tube and turn on the current. Relieves pain and improves condition.

PLATE 310.—In this manner children may be placed in the large body Solenoid and given agreeable and beneficial treatment in convalescence from all exhausting diseases. As no undressing is necessary and no irritation is caused the child it is a measure of great convenience as well as value. The sedative action of the potent Alternating Current taken directly from the electric-light circuit has also benefited acute cases. For instance, a girl with pertussis was placed in the Solenoid daily for a half hour and it seemed to modify the disease materially.

currents are obtained. Three methods of treatment are used for these cases.

"1. Auto-conduction. The patient is placed in the large Solenoid which is charged from the coil and induced currents are set up through the tissues within the electrical field.

"2. Auto-condensation. The patient is placed on the couch as shown on page 627. (This method enables the coil to imitate the familiar general electrification of the Static machine in which the current charges the patient on the insulated platform. The effects of the two methods resemble each other and vary less in principle than in dosage. Small apparatus of either kind will produce little effect, while efficient apparatus giving large currents will have great therapeutic energy.)

"3. The Resonator of Oudin. This is a Solenoid ending in a spear which enables the coil to imitate the familiar Static spray application. The other end of the Solenoid is connected to the outer coating of the Leyden jar.

"These are the methods used in consumption. Long sittings produce a rise in temperature. Dosage is regulated by the reaction. Ten minutes is the usual time for a treatment. The bacilli may increase for a few weeks and then disappear. Daily treatments are given for the first month; for the second month, three times a week; for the third month, twice a week. Three months is usually sufficient to cure the early stage." Williams considers it necessary to administer the general electrification till, at each séance, the body temperature is raised to above 101.4° F., and this usually requires ten minutes.

A further contribution to the action of currents of high-frequency upon tuberculosis was published in July, 1901, by Dr. Riviere of Paris, whose large equipment affords him ample scope for investigation. We here present the substance of his report:

"Since the memorable experiments of Professor d'Arsonval and Dr. Charrin I have been fully persuaded that tubercular patients would derive great benefit from High-Frequency treatment. I have had the opportunity to treat many cases of pulmonary tuberculosis by means of the large Solenoid of d'Arsonval. They have been treated for twenty minutes every second day and I have invariably been able to verify the results announced by Professor Doumer of Lille to the Academy of Sciences, February, 1900, and by our learned confrère, Dr. Oudin. Their technic seems superior to mine, and I have used it ever since.

"Patients under treatment have felt their general health improve from day to day, and in certain cases the physical signs of the lesions have completely cleared up. I ought to add that my patients have followed at the same time the classical treatment of phthisis and I have also alternated my High-Frequency séances with exposures to X-rays and inhalations of ozone. It has seemed best to stop this treatment during febrile or congestive aggravations. Chronic cases have responded best to the electrical treatment.

"I now wish to call attention to two convincing results which I have obtained in localized tuberculosis. The first was a man, aged fifty-five, with tuberculous ulcer a little less than an inch below the middle of the left clavicle. It measured three centimetres long and two centimetres wide by one and one-half centimetres deep, and was filled with yellowish-green cheesy purulent matter. The edges were indurated and two of the axillary glands were large as pigeon's eggs. It began in a painless infiltration of the skin which took on a nodular appearance and broke down and ulcerated.

"I commenced by applications of the High-Frequency spray (effluve) from the Resonator of Oudin. The ulcer became less painful; the discharge changed from purulent to serous; the base took on copious red granulations, and in less than a month it completely healed and became covered with a soft and fine white membrane. This process of healing was in marked contrast to what had occurred on the opposite side with a similar ulcer three years before, which left a hard cicatrix like a small keloid after a whole year of scraping, and other treatment. The daughter of this patient recovered from the first stage of consumption under the combined influence of High-Frequency auto-conduction in the large solenoid and X-rays. Her age was thirty, and her treatment lasted three months.

"Two years ago I had under my care a young man with an arthritis of the knee of a suspicious nature. The epiphyses were first attacked and the joint was much enlarged. The articular surfaces of the bones were thickened; the peri-articular structures were swollen; the limb was a little bent at the thigh; and there was pain from time to time. After eighty sittings of localized High-Frequency treatment the joint had recovered its functions, the knee had diminished in size, the swelling of the soft parts and the pain had completely disappeared, and the general health seemed excellent. The patient left for the country, and two months later wrote that his health had been completely re-established. I am persuaded that he was suffering at the beginning from tubercular arthritis. The applications were made by means of one or two dampened plates attached to one or both extremities of the small solenoid.

"But the most convincing case of the favorable action of High-Frequency currents in localized tuberculosis is the following: Mr. ——— had been sent me two months previously. He had been operated on a year before for tubercular glands of the neck. There was now a recurrence. He had five cervical glands rather smaller than a hen's egg and there were four fistulous openings freely discharging.

"I gave him a daily application of a long spray from the Resonator of Oudin for five minutes. From the next day the discharge was changed in character; it became serous instead of purulent, and at the end of the tenth application the fistulas had dried up. The swelling of the neck steadily disappeared, and on the thirteenth application at the end of one month's treatment there remained only one sublingual gland enlarged, and it was only the size of a pigeon's egg.

Business obliged the patient to suspend treatment for a month. He then returned with a fistulous discharge which seemed to come from the gland in question. After four fresh applications of the spray the fistula dried up and the gland considerably diminished in size. He left then for the country, and on his return we shall hope to complete a cure. This patient, like all the others who have been similarly treated, reported that under the influence of High-Frequency currents his strength increased, and sleep and appetite were equally improved.

"Since the interesting communication of Professor Doumer with reference to the cure of anal fissure and fistula, I have had the opportunity of trying the procedure in such cases on six occasions. The cases of fissure got quickly well; two fistulas disappeared after a treatment of one or two months. In the first instance I introduced a small stylet into the fistulous track; this stylet being attached to the Oudin resonator. After four applications of this kind I used a glass cone filled with metallic filings, and attached to the resonator (condensing electrode). Two other patients who suffered from complete fistula did not complete the treatment. But in every case the purulent and fetid discharge of the first day gave place to a comparatively slight serous discharge with a less offensive odor; the pain rapidly disappeared. In the last two cases, to accelerate the treatment, I had also used creosoted suppositories.

"I might add that at present I have an English lady under my care who has an osseous fistula in the heel. Radiography showed a small opaque cone-shaped excrescence half a centimetre in length at the lower end of the os calcis. After three weeks' treatment by localized high frequency the fistulous opening seemed to have dried up, pain had disappeared and walking was much easier. During the last few days she has benefited by the bi-polar effluve of the new d'Arsonval transformer. The discharge, although it had disappeared, has unfortunately become re-established, and therefore I am not able to affirm that there will be an eventual cure. But the three radiographs which I have taken show that the osseous changes have gradually but completely disappeared.

"It follows from the foregoing that high-frequency currents exercise a certain curative action upon tuberculosis, pulmonary and localized. The microbe cannot resist the repeated application of these currents; its reproductive power and the virulence of its toxines become attenuated, a fact which had already been proved by the laboratory experiments of Professor d'Arsonval. It appears that, at the same time, the human organism under the influence of these currents gets stronger, its enemy, the microbe, grows weaker. It is also probable that under the influence of this form of electrization the beneficent action of the phagocytes increases in activity. It thus appears evident that in these conditions the attacked organism recovers its strength and (aided by phagocytes) finally prevails against the bacillus whose vitality the electric concussions had already imperilled. It is, therefore, sufficient to place the patient in the best conditions of food and hygiene to avoid the return of the diseases. It is in this way that some of my patients sent south after the treatment are now completely recovered. I regret that I have never had the opportunity of treating true white swelling, or Pott's disease. I am under the impression that these two localizations of tuberculosis ought to be materially influenced for the better by the spray, mono-polar or bi-polar, of the Oudin Resonator (Rochefort model) or of the new d'Arsonval transformer." (*Journal of Physical Therapeutics*, London.)

Another corroborative note was presented to the French Academy of Sciences in April, 1900, by Dollmer, describing facts which demonstrated an improvement in the condition of tuberculous patients subjected to the action of High-Frequency currents.

"After five or six applications the night sweats diminish and totally disappear after about fifteen treatments. An examination shows a systematic diminution in the number of bacilli present in the sputum. After regular treatment the appetite returns, emaciation is stopped, and the body weight increases. Experiments were made on twenty-seven patients of both sexes, and in various stages of the disease, and the constancy and clearness of the observed results left no opportunity to doubt that the results were actually accomplished as stated."

The following report of clinical work in London was published in this country on January 25, 1902. The captions and some part of the account are omitted. While these accumulating evidences of the efficacy of electric-currents in the early stages of tuberculosis are received as new and wonderful by practitioners who observe them for the first time, yet it must be noted that they all have an old familiar resemblance to results reported with high-potential currents down the whole line of nineteenth-century experience (and nearly half of the eighteenth-century) with static electricity in pulmonary disease. It widens the scope of therapeutic resources to be now able to obtain these results with attachments for coil currents.

"Experiments are being made on a most elaborate scale in London, with high-frequency electrical currents, in the treatment of consumption. It is stated that some remarkable results have been achieved. These experiments, for the most part, have been conducted by Dr. T. J. Bokenham, an eminent West End surgeon, in the course of his private practice, but with the knowledge and approval of leading consumption specialists. Dr. Bokenham has had fitted up a most elaborate apparatus for the production of electricity in the particular form in which it is used, the net result of which is that a current of 80,000 volts is produced, of such high frequency and administered

PLATE 311.—Showing a sick child placed in large solenoid for tonic effects in asthenia.

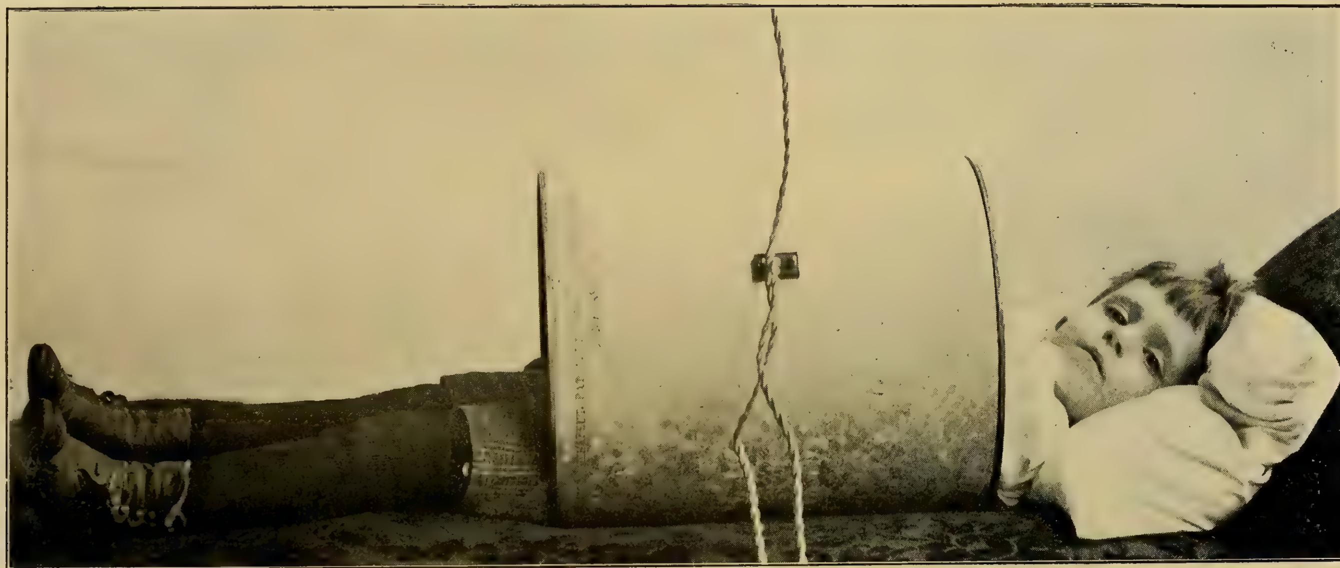


PLATE 312.—Showing boy recumbent on couch with solenoid drawn over trunk of body for general tonic effects during convalescence. Patient can turn to any desired position and recline on either back or abdomen.

PLATE 313.—Apart from bedside use the general tonic action of the alternating current may be well utilized for professional men by the aid of this convenient solenoid. This plate shows a gentleman at his desk with feet in tube for simple warmth in cold weather, or the relief of any painful condition. He can swing it under the desk and keep at his work. A tube on the arm is shown also to illustrate the use of the solenoid bv writers who suffer from fatigue of the pen muscles. Owing to the general nervous tone imparted to the system by the auto-conduction of the current this resource would be an advantage to many busy physicians for self-use in their own offices during periods of strain and anxiety.

PLATE 314.—This Plate illustrates a prescription of either foot or arm solenoid for half-sick women at business, stenographers, typewriters, secretaries, etc. The special indications need not be repeated here. The application of a body solenoid around the pelvis during dysmenorrhœa has afforded great relief to the pain, and worn a half-hour daily between periods has brought about an improved state of the circulation in simple cases of functional types.

in such small quantities that the consumptive patient may receive it without the slightest injury.

"By one method of this treatment the patient is laid in a reclining position on a chair. The chest is laid bare, or partially bare. The back of the chair is insulated. Thus when the patient receives the current from the electrical machine a complete electrical circuit is established through the floor. The current is applied from a brush electrode held a few inches from the body. When the apparatus is set working, electricity is discharged from the end of the brush with a faint smell of ozone, and the appearance of a number of lines of electrical blue fire. Thus is the current passed through the chest, a slight warmth only being experienced by the person receiving it. This is the mono-polar method.

"By the other method, the one which Dr. Bokenham is inclined to favor, the patient, in the same posture as before, simply takes hold of a handle like that of an ordinary galvanic batterv and receives the current till he is what is described as super-saturated with electricity. He feels nothing whatever, but, if the attendant touches his skin, sparks fly out in all directions. When he is using this treatment Dr. Bokenham applies his finger to the most affected parts of the patient's chest, thus concentrating the electricity there for the time being.

"With both systems the application lasts from ten to fifteen minutes at a time. The treatment is undergone three or four times a week, or daily. The first result is, on each occasion, that there is a pronounced rise in the patient's temperature. Usually it rises two or three degrees, but in at least one case the rise has amounted to as much as six degrees. The improvement in the patient in some respects is beyond all doubt.

"Dr. Bokenham's experience is that in very bad cases of consumption the cough has been greatly reduced, night sweats have disappeared, the appetite has improved, and there has been a great gain in weight and general health. So that even if the consumption bacilli have not been destroyed, it is certain that their virulence has been much decreased; that they have been brought under control and that the patient has felt cured. In one case a remarkable result has been effected by it. A gentleman was, after every other sort of treatment, to all appearances in the last stage of consumption. It was said he had no healthy lung tissue left to breathe with. His business had been abandoned. For a long period he had practically been confined to his room. He received the electrical treatment daily. He has now to all appearances recovered, and he has resumed his professional work."

An Alternating Current Solenoid.—The therapeutic apparatus shown in the next eight Instruction Plates (307 to 314) will be an entire novelty to the majority of the medical profession. It is new. It is strikingly simple. It costs as little as third-rate faradic batteries, yet is a scientific instrument producing effects resembling the general physiological actions derived from d'Arsonval's high-frequency autoconduction solenoid. It also combines with the field of electro-magnetic stress in which the patient is placed the auxiliary action of low dry heat. To a very useful extent it is a "hot-air" apparatus as well as an electrical appliance. Wherever facilities exist (or can be procured) for screwing the terminal cord of the solenoid into a lamp socket with an exciting current of the alternating type this apparatus can be made almost indispensable to both medical and surgical practice. To derive a comprehensive idea of its actions study the physiology of heat, general static electrification, general faradization, galvanic electrotonus, the sinusoidal bath, and high-frequency electrization. The indications for these beautifully obtained actions as modified by this alternating-current solenoid are numerous.

It requires no technical skill. The medical judgment of the practitioner suffices to prescribe the treatment for perversions of nutrition and states below par, and the only other requirement is the alternating current. Dosage is made automatic by the initial construction of the solenoid. It is the nearest approach to placing "electricity on draught" for general-health and tonic purposes that has yet come to our notice. As an active practitioner may have several nurses at a time out among his patients under his directions and subject to his control so the same man might keep a score of these solenoids under his direction in both office and family practice. It is also especially adapted to institutions. Confident of the merit of the appliance and esteeming its worth we do a service to the profession to here make known and teach its uses.

Stated in the simplest terms and without technicality this therapeutic apparatus consists of an induction coil made to be worn *around the body* or part of the body instead of being wound in the usual manner over a primary helix or core. In other words, it is a solenoid lined with a brass tube and inclosed in an iron jacket. In appearance it is a short section of hollow tubing and these tubes are made in a series of seven sizes adapted to admit the arm, leg, head, feet, chest, and trunk of the body. It is almost distinct among therapeutic apparatus for the reason that its operation is automatic and requires no technique beyond that of turning on the current. To secure a remarkably high class of physiological actions and the relief of many forms of pain the solenoid makes only the same demand upon the physician's manual skill that is made by the electric-light at his office desk. To secure the light he must switch in the current, and that is all he need do with the Burry solenoid. It can scarcely be abused and is difficult to injure, and offers a combination of advantages which actually give to the physician for domestic practice among his patients a *scientific realization* of many of the fictitious claims put forth in the advertising circulars of quack electrical devices sold to the credulous laity. This may be deemed high praise, but those who use the appliance with the judgment of educated electro-therapeutists (solely within its capacity, and remembering that it does not contract muscle-fibres and has no sensory effects), will find that it supplements prescribing in gratifying and numerous ways. In a moment we will consider some of these ways.

Wherever an alternating street current is available for electric lighting a lamp can be unscrewed and in its place, connected by a flexible cord and plug, the solenoid is ready for use. The continuous commercial current will not directly operate this solenoid nor can it be excited by a high-frequency apparatus, but when no alternating circuit is within reach and only the Edison constant current supplies the lighting mains a motor-generator " transformer " will enable the physician to use the solenoid with the direct current. During the past three years the inventor has made many tests of windings for various phases of current and has conducted an empirical clinic in which some 2,000 persons have been treated. The resulting actions have closely resembled those of the similar applications of the more elaborate device of d'Arsonval, which in nearly the same manner places the patient's tissues in a field of " auto-conduction." An incandescent lamp held in the centre of the solenoid will glow without contact with any circuit. The most marked physical action is the gradual heating of the appliance. With windings suited to the current this heating is regulated so as to attain its maximum in about twenty minutes, and does not exceed a comfortable warmth.

Experience has led the maker to settle upon the following graduated scale of capacities for his various sizes of solenoids:

Arm size	1	Ampere.
Knee size	1½	"
Thigh size	1¾	"
Head size	2	"
Feet size	2½	"
Chest size	3	"
Body size	3½	"

With construction adapted to these currents the heat during treatment rises to comfortable tolerance, and in many cases is a factor of benefit to the patient. While the smaller solenoids are safely used in the ordinary lamp socket, yet it is the author's experience that it is much less liable to blow out fuses if a baby knife-switch is substituted for the usual lamp-switch in all electrical office apparatus employing more than one ampere of current. This is especially true when more than two amperes is used. In the common and lightly constructed lamp-socket the terminals are too close together to resist the arc of the *break* with heavy currents, while the knife-switch is arc-proof. A proper switch is a great economizer of annoyance. Clinical tests of therapeutic actions have been made with the following:

One hundred and four volt, 125-cycle alternating commercial current.

One hundred and ten volt, 60-cycle alternating commercial current.

Seventy-two volt, 25-cycle alternating commercial current.

The lower frequencies have given the best clinical results. Frequencies of 200 and upward short-circuit in the solenoid and produce no effects within the tissues. A 125-cycle current is less sedative than currents of sixty and twenty-five cycles, and these latter are preferred where they can be obtained. All manner of mechanical breaks have been tested in the attempt to place the solenoid at the command of physicians relying on constant currents and primary batteries, but none are satisfactory. The rotary break is inadequate and electrolytic interrupters do not work with the appliance. No rapid interrupter appears to set up the essential conditions in the electrical field and tissues.

It has been noted that the lower frequencies produce the more sedative effect and not only relieve pain better, but in their tonic action are gratefully tranquillizing in certain neurasthenic states which may be irritated by the same solenoid actuated with a 125-cycle current. From a total of over 30,000 applications of all kinds made upon all classes of patients offering themselves at a free dispensary and without any attempt at selection, and often extending experimental applications for one, two, or more hours at a time, and continuing them daily for weeks and months to determine if harm could result, it would appear that in the hands of any physician exercising the simplest medical judgment the appliance is harmless. Such local or systemic conditions as are aggravated by heat may be avoided, but, in general, during anæmic and cold conditions of chronic diseases and during convalescence, the tonic action of the alternating current may be thus applied to the patient with great advantage.

This is particularly true of states of defective nutrition, and of such painful states as arise chiefly from disordered functions. Every well-read physician should now be familiar with the work of high-frequency currents in pulmonary tuberculosis, and this solenoid affords a means of almost exactly duplicating some of these superb results. Results in many cases of rheumatism have been excellent, and this has been true of certain very obstinate types. Among the pains relieved during the maker's three years of empirical tests have been those of floating kidney, chronic cystitis, neuralgias, dental caries, headaches, phthisis, rheumatism of all forms, gout, etc.

It is not necessary here to repeat the therapeutic principles governing the indications for a prescription which is of a *general sedative-tonic* nature, with such special actions as promote the ultimate processes of nutrition and tend to restore an incomplete metabolism to normal. The symptomatic reliefs that go along with these actions (even in incurable chronic diseases) will gratify the patient and will often appear astonishing to the prescriber accustomed to drugs for his tonic, alterative, and anodyne effects. They are so well known to the student of fine mechanical massage and of electro-therapeutics, that they call for no further remark in this section.

If employed for no other purpose than to aid in the treatment of chronic rheumatisms the solenoid would be a boon to many practitioners and their patients. If used solely to hasten convalescence it would save many days of disappointment to all concerned. As a mere pain-reliever there are many cases it will not reach, but there are also an immense number of others that would find it a source of positive comfort with none of the evils of narcotic and depressant drugs. It has no local adaptations through any familiar *electrodes*, for it is simply and solely a short and very coarse-wire induction coil carrying alternating currents around the body under conditions which establish a field of induced currents through the patient's body within the solenoid (coil) with its axis at right angles to the lines of force. The Instruction Plates 307 to 314 sufficiently teach the methods of employing the apparatus.

Says Renaud, in a recent contribution to the subject:

"One of the most remarkable of the results of the beautiful researches of M. d'Arsonval upon the physiological effects of 'High-Frequency' currents after he had obtained more powerful methods was the discovery of *auto-conduction*, a simple and effective way of producing powerful induced currents capable of deeply penetrating the living organism, yet without any application of electrodes upon the patient, or any direct relation of the latter with the electrical apparatus. The phenomena are obtained by means of a *solenoid*, and the exciting current may be a large induction coil, a Static machine, or an alternating current transformer. When we charge the coil with the alternating current it becomes necessary to cut the arc as soon as it tends to establish itself, either by a magnetic field or by an air-jet. With this current and under this arrangement the effects are the same, that is, the positive and negative waves produce the same inductive effects. The oscillations are renewed from 120 to 150 times a second according to the frequency of the current employed (60 to 125 cycles)."

Taking then the solenoid of Burry and exciting it by an alternating current as taught we have very nearly the same physiological action of auto-conduction as that claimed for the solenoid of d'Arsonval when excited by the high-frequency attachment of an induction coil. As the main features of High-Frequency therapeutics have been taught earlier in this section we need here only consider that in the simple device excited by the alternating street current as described we have the valuable effects of the more famous method. This, of course, refers only to the one technic. The varied uses of electrodes possible with a complete high-frequency equipment are not administered with the solenoid, and are an entirely different technic.

Owing to its simplicity and general usefulness and the fact that it has already been subjected to three years of test before being put before the profession, it would seem reasonable to assume that every practitioner commanding the requisite exciting current could employ it to his advantage. It is an appliance which should be kept within the profession and out of the hands of charlatans. Costing but about the same scale of prices as low grade and almost worthless "Medical Batteries," too often bought by patients on mistaken advice, this scientific solenoid will contribute vastly more to the welfare of humanity than all the thousands of faradic boxes purchased by the *laity* every year. Its therapeutic activity and efficient impression upon the tissues is not a merit of the device *per se*, but is a consequence of the fact that the device is rendered active, not by one or two insignificant "dry cells," but by the great therapeutic properties of the potent alternating current, *one of the most energetic agents of the entire materia-medica.* The difference is akin to the difference between attaching dry cells to a trolley car and connecting the same car with the current from a dynamo.

Author's Note.—In closing this latest work from my pen a few words of explanation are necessary. To present the important knowledge in the most compact manner, as physicians need, the text has been condensed by careful editing into 350 fewer pages than as first written. The difficulties in the way of carrying out my full wishes in the Photographic Instruction Plates were insurmountable. After many delays, broken promises on the part of others, and almost prohibitive expense, the volume must go to readers as it stands.

Viewed from the labors of the author the individual reader may well regard it as nearly a clear gift in its great mass of information, much of which cannot be got in any other way. Had it been possible to manufacture the finer work intended the cost must have been doubled.

In regard to previous writings, it daily appears that many are misinformed as to the scope of my several books and it is necessary to relate the facts. The little quiz-compend on "Rudiments" (165 pages) is simply a primer for the undergraduate student to read. It aims to correct his judgment and start him right when he begins to study practical methods, but it does not teach technics at all. It was not written for the physician, but for the medical student, and serves its purpose if it prevents him from leaving college with prejudice against a great therapeutic agent. He can study clinical methods afterward. My Manual of Static Electricity (670 pages) was written in February, 1897, and has never been revised. It sold out and was reprinted four times, but the four editions were the same except as to a few verbal corrections. Its X-ray part was written about one year after the beginnings of X-ray work, and should now be charitably laid aside. Most writings of five years ago on this subject are obsolete to-day. Working then with a smaller static current we obtained many ideas which time has shown do not apply to the type but to the dosage of current, and some of those early theories have not only been misquoted, but have been twisted far out of my original design. This work, therefore, displaces the X-ray part of my Static Manual.

The author's earlier writings on therapeutic uses of static electricity now seem primitive and not half complete. Fully twice the clinical work described can be done with this flexible agent, and a wide range of methods now employed do not appear in the Manual, but await my leisure to write them up. Those who have any copy of this historical work may prize it beyond its cost, as no more will ever be printed. It served its pioneer purpose and has been outgrown. My work on The Treatment of Disease by Electric-Currents (1,100 pages) was written early in 1897, and has not been revised, though now in its second edition. It teaches the greatest variety of clinical methods for the three chief currents (Static, Faradic, Galvanic) that were in use at the time of writing. No other work has yet taken its place, though it needs many additions to its technics.

My clinical book on "Correct Technique" in electro-therapeutics (314 pages) was designed to supplement my previous larger books and bring them up to date by additions to methods of using all four currents, the sinusoidal being included. It was written in August, 1900. It is an absolutely unique book of clinical instruction such as was never written by any one before. No matter what other works on electricity the reader may have he needs this to direct his study in practical experiments on himself. It puts into written form much of what the author taught in regular clinics before demands on his time compelled him to abandon them. Therefore, with the exception of static therapeutics placed in the "Treatment" book from the Static Manual none of the five major volumes repeat each other. As some have thought that the large volume contained all the rest the error is here corrected.

We may also add that those who know from personal experience what it is to write amidst the distractions of busy private practice, and know, too, the little recompense that fame brings the medical author, will appreciate the missionary spirit which has induced me to record my teachings for the benefit of beginners whose troubled path I once trod myself. Defects are more apparent to the writer than they can possibly be to others, but if any book was held back from press till the author had time to make it satisfy him it would never reach those who need it, defects and all. Fine literary work and attention to patients do not get on well together, and when it is considered that the task of writing the text is but one-fifth of the work which such a book as this devolves upon me I must either write no books or write them as best I can, craving indulgence for faults that are unavoidable under the circumstances. The above list does not take into account pamphlets and lesser writings, or papers written for Correspondence Instruction Courses. With time at command, and wider support from the general medical profession, the author could more adequately present the important subjects on which he has written, hitherto under very difficult conditions and under disadvantages which have destroyed many of his plans for improving and illustrating the text.

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EXTRACTS FROM REVIEWS OF "THE TREATMENT OF DISEASE BY ELECTRIC CURRENTS."

"When Professor Monell issued his work upon static electricity, it was taken up by the medical profession as few books upon electro-therapeutics have been, and almost from the day of issue became the work of reliable reference with not only multitudes of general practitioners, but also with the specialists in this line of medicine, and especially with the medical teachers of America. When the announcement was made some weeks ago that a general work upon the entire subject of electricity in medicine was in process of preparation by Dr. Monell, a stir of interest passed over the profession, and the mere announcement that the work has now been published will bring for it a very large sale. The work stands forth as one of the most striking medical productions of 1897."—*Medical Sentinel.*

"To the average medical man this volume will prove a revelation of a most remarkable kind. While all have a general knowledge of the fact that electricity can be used to great advantage in some diseases, but few are aware of the vast scope of usefulness it can subserve. We could not in the short space allotted us for this review give a tithe of the names of complaints benefited by this mode of treatment according to the author. His enthusiasm, too, is contagious, for as the reader proceeds he is unconsciously carried away into believing without seeing. He is a clear, forceful writer, and puts his subject before the reader in a way that cannot be misunderstood. His directions are all examples of perfect lucidity and just such as the practitioner needs when beginning the study of so fascinating a subject. The work of a good static machine and of a family battery is absolutely as incomparable as the medical advice of an Olser with that of a savage. This book should be in the hands of every person interested in electro-therapeutics."—*American Medico-Surgical Bulletin.*

"Every page of the book is *practical therapeutics.* Every chapter is a clinic in itself. It is a book that physicians have long desired, and is the first work upon the subject which presents in a single volume the special and comparative merits of all forms of medical currents. To the practitioner who seeks to inform himself of therapeutic development for consultation purposes, or for personal use of electrical apparatus, this volume is practically indispensable."—*The Medical Brief.*

"Another extremely valuable work on electro-therapeutics has been launched by the same author as the recent publication, 'Manual of Static Electricity in X-Ray and Therapeutic Uses,' which has attracted world-wide reputation thus early for its clearness of description and usefulness to the general practitioner."

"It would be impossible for us to specialize the headings of the seventy chapters in this volume in the space allotted for this review, therefore it must suffice to state that every known modern employment for faradic, galvanic, and static electricity, and their therapeutic indications, are detailed in this volume with *conciseness of language* and *minute directions of application* so that the general practitioner who runs may read and understand."

E. R. Pelton, Publisher, 19 East 16th Street, New York

"Probably no book on electro-therapeutics—and we say it conservatively—has ever equalled this volume for value to those of the profession who would use electricity as a therapeutic agent, and he who does not use it at this age is certainly not up to the times in his profession.

"We therefore heartily recommend this volume to our readers, believing that they will not be disappointed in adding it to their libraries."—*Medical Times and Register.*

"The general practitioner wants his information condensed as much as possible. The volume before us is clearly and simply written.

"It may be said that on the whole the volume before us is written in a more temperate spirit than usually prevails when the subject of electricity is treated, and it will prove a safe and useful guide to the general practitioner."—*Maryland Medical Journal.*

"Dr. Monell has given us a book that is eminently practical as a guide to the student of electro-therapy. It is based very largely on his own work and experience, and is to a high degree common sense, not only in practice, but in theory; that is, it is truly scientific in that it rests therapeutic principles on the present well-known laws of electric constants and the varieties of action on tissues. The present volume is complemental to the author's work on static electricity, and the two form the most complete and practical exposition at present existing of the subject of electro-therapeutics."—*Cleveland Medical Gazette.*

"Dr. Monell, the author of this work, is an inveterate worker and prolific writer. It is only a few months ago that it was our privilege to receive his large work on 'Static Electricity in X-Ray and Therapeutic Uses.'

"One cannot in a brief review more than hint at the scope of the work, so numerous are the points discussed. The indications for the use of the various currents of electricity and the results that can be obtained have now reached such a condition of exactness that we must now regard this means of treatment as having wider application than any other.

"When one sees how much can be written on a single therapeutic agent like electricity, it excites wonder to know why it is not more generally used by practitioners generally. Readers of this book may become versed in all the technical uses of this potent remedy and cannot fail to catch the enthusiasm which characterizes this author's work."—*Canada Medical Record.*

"We find in this volume a condensation of facts which physicians have long sought in vain. Dr. Monell has cleared away in a few pages the perplexities that have befogged the source of knowledge. The quibbles, the confusion, the vague meanings which have hitherto characterized electro-therapeutic literature are here wholly unmasked—the subject being treated with the plainness of the Anglo-Saxon tongue.

"The book abounds in commonplace similies which are used for the purpose of imparting accurate meaning and setting aside all ambiguity and doubt. In every paragraph the reader finds something new, and so easily does he grasp the thought that with hours of reading he does not tire.

"The author betrays a familiarity with the subject not equally enjoyed by any other writer. The writing is essentially Monell. Every sentence bristles with the evidence of self-conviction won by labor, experience and thought. His language is simple, pure and rich. This book marks an essential feature, in that it makes no claim whatever in its teachings, but simply states the demonstrated action of electricity.
